Primary Frequency Response Incentive arrangements - Discussion Paper

August 2021

Investigation into the feasibility of incentivising primary frequency response

A report prepared for the Australian Energy Market Commission

Important notice

PURPOSE

This document considers the feasibility of potential options to incentivise the provision of primary frequency response in the National Electricity Market, to help inform discussion with the Australian Energy Market Commission in its consideration of proposed changes to the National Electricity Rules.

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VERSION CONTROL

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Executive summary

This discussion paper has been prepared at the request of the Australian Energy Market Commission (AEMC) to inform its "primary frequency response incentive arrangements" rule change consultation. The AEMC's 2020 Mandatory Primary Frequency Response (MPFR) rule change introduced obligations for technically capable scheduled and semi-scheduled generators as an interim arrangement until June 2023 to allow for further work to be done to understand power system requirements and consider enduring arrangements.

The discussion paper assesses the feasibility of policy pathways involving different PFR deadband and incentivisation options across these pathways – such as a new market service or improvements to existing cost allocation mechanisms.

It is intended to be read in conjunction with AEMO's separate Technical White Paper exploring the power system requirements for PFR.

Based on this assessment, the discussion paper finds:

- Options within policy pathway 1, retaining tight MPFR obligations as part of enduring PFR arrangements, provide an effective control base, over which incentivisation options can focus on improving the economic efficiency of provision.
- The preferred option supplements tight MPFR with improvements to Regulation frequency control ancillary services (FCAS) cost allocation, including to reward good performance, making it "double-sided". This combination should minimise the need for PFR, while ensuring it is provided effectively with least effect on individual providers.
- Policy pathways with wider PFR deadbands reinstate poor frequency control under normal operating conditions experienced prior to the MPFR rollout. Incentivisation options aiming to restore effective control would require complex specification, dispatch arrangements and pricing – not guaranteed to provide the same or improved frequency control or economic outcomes as the preferred option.

Contents

Tables

Figures

1. Introduction

1.1 Context

AEMO has prepared this discussion paper for the Australian Energy Market Commission (AEMC) to inform its consideration of incentive arrangements for the provision of primary frequency response in the National Electricity Market (NEM) , following conclusion the current Mandatory Primary Frequency Response (MPFR) interim arrangements in June 2023, applying to technically capable scheduled and semi-scheduled generators[1].

In 2020, the AEMC amended the National Electricity Rules (NER) to require units to operate with tight deadband primary control, referred to as tight MPFR, with a sunset date of June 2023, after which the requirement will cease to apply. The reason for the sunset was to allow time to develop enduring arrangements for PFR that should apply beyond this date.

The discussion paper is intended to be read in conjunction with AEMO's separate Technical White Paper exploring the power system requirements for PFR. It provides AEMO's views on the need for, and feasibility of, different policy pathways and incentivisation options proposed by the AEMC, including possible use of the Regulation frequency control ancillary services (FCAS) cost allocation system described in the Regulation FCAS Contribution Factors Procedure[2]. In this document, "Regulation FCAS cost allocation system" refers specifically to the existing implementation as envisaged under NER 3.15.6A(k). While this has traditionally been termed 'causer pays', the current application does not fully reflect a causer pays concept and AEMO has not used that term to describe it.

The paper proposes an assessment approach and provides initial commentary on how the different elements of the Regulation FCAS cost allocation system may be amended to incentivise the provision of tight MPFR. The discussion is not a high-level design, but a description of a policy position that may be suitable for the drafting of amendments to 3.15.6A of the NER.

1.2 Prior reading

This discussion paper has been drafted assuming a level of prior understanding of existing FCAS arrangements in the NEM, including their dispatch, pricing, and cost allocation.

It accompanies AEMO's separate Technical White Paper examining the role of PFR within the broader frequency control chain, which establishes the technical characteristics of effective PFR and outlines how this can be maintained as the power system continues to transition into the future. The Technical White Paper emphasises the importance of tightly managed control with widespread response for establishing effective aggregate frequency responsiveness under normal operating conditions.

Effective PFR establishes a strong control base, supporting the action of slower-designed controls and enabling optimised, robust outcomes across the frequency control chain. Primary and secondary controls do not act independently or in sequence; rather they are continuously active, complementing each other to provide effective control of frequency.

The reader is also expected to have read the following related documents:

- AEMO's rule change request for MPFR and related advice provided by Dr John Undrill[3].

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[1] National Electricity Amendment (Mandatory primary frequency response) Rule 2020 No. 5. Final rule and all proposal, consultation and determination documents, at https://www.aemc.gov.au/rule-changes/mandatory-primary-frequency-response.

[2] Regulation FCAS Contribution Factors Procedure, at https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/ancillary_services/regulation-fcas-contribution-factors-procedure.pdf?la=en.

[3] Dr. John Undrill, Notes on frequency control for the Australian Energy Market Operator, 5 August 2019, at https://www.aemc.gov.au/sites/default/files/2019-08/International%20Expert%20Advice%20-%20Notes%20on%20frequency%20control.pdf.

- AEMC Final Determination for the MPFR rule[4].
- AEMC consultation papers on the PFR incentive arrangements rule change (September 2019, July 2020)[5].
- AEMC directions paper for the frequency control rule changes (Dec 2020)[6].
- AEMO Interim Primary frequency response requirements document (June 2020)[7].
- AEMO Regulation FCAS Contribution Factors Procedure V6.0 and the related report (2018)[8].

1.3 Purpose

The purpose of this discussion paper is to formally provide AEMO's opinion, at the time of writing, on the need and feasibility of different policy pathways and incentivisation options for the provision of PFR following conclusion of the current MPFR arrangements in June 2023.

1.4 Structure and sections of this paper

The following is a summary of each section of this paper.

Section 1. Problem

This section explains that the discussion paper draws on the engineering conclusions in AEMO's Technical White Paper to investigate the control and incentive effects of the implementation of tight deadband MPFR. The investigation separates the problem into instituting control and then devising appropriate incentive arrangements, rather than the more complex proposition of trying to use incentives to institute control.

Section 2. Defining the concepts

This section defines the concepts related to provision of market ancillary services, cost allocation systems, and a new market service for PFR. These definitions are used to outline the purposes and assumptions behind each option.

Section 3. Evaluating the options

Two groups of options, called pathways, were put forward by the AEMC. The options within each pathway are similar, bar one group having a tight deadband of +/-0.015 hertz (Hz) and the other having a deadband wider than +/-0.15 Hz. The evaluation uses the approach taken to investigate the problem and recommends Option 1b, which retains tight deadband MPFR to resolve the control element of the problem and, to resolve the incentive element (of the problem), recommends improving the existing Regulation FCAS cost allocation system.

Section 5. Recommended option

This section further describes Option 1b, with the specific recommendation to include payments for good performance within the Regulation FCAS cost allocation system, making it "double-sided". Although this document does not provide a detailed design for a new system, subject to necessary limitations and requiring further assessment and consultation, AEMO considers it practical for a replacement system to be implemented as envisaged in this paper.

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[4] AEMC, Mandatory primary frequency response, Rule determination, 26 March 2020.

[5] At https://www.aemc.gov.au/rule-changes/primary-frequency-response-incentive-arrangements.

[6] AEMC, Frequency control rule changes, 17 December 2020, at https://www.aemc.gov.au/rule-changes/fast-frequency-response-market-ancillary-service.

[7] At https://aemo.com.au/-/media/files/initiatives/primary-frequency-response/2020/interim-pfrr.pdf?la=en.

[8] Procedure and associated specification at https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/system-operations/ancillary-services/ancillary-services-causer-pays-contribution-factors; November 2018 final report at https://aemo.com.au/en/consultations/current-and-closed-consultations/causer-pays-procedure-consultation.

Appendix A1. Primary Frequency Response – FCAS

The first appendix investigates the feasibility of implementing a new market service PFR. AEMO has identified that PFR for normal operation – that is, in absence of a significant contingency – is not readily suited to the current deployment of Contingency FCAS. This is because the Contingency FCAS services procure capacity reserves to specified frequency error, unlike primary control for normal operation, where a high aggregate frequency responsiveness in megawatts (MW)/Hz prevents a significant deviation in frequency. This suggests any FCAS service for PFR would also need to include a system-wide requirement for aggregate frequency responsiveness in MW/Hz.

Further, AEMO discusses whether faster response may be required to compensate for the slow response provided under Option 1b. These factors make it difficult to define the requirements of a new PFR FCAS service: to procure reserve capacity in MW, droop response in MW/Hz, speed in seconds, or all three?

Appendix A2. Evaluation of options

The second appendix provides further details on how each of the options compare.

2. Problem

2.1 Discussion on mandatory primary frequency response

It has been argued that requiring primary control to be provided at a very tight deadband would distort market arrangements. The suggestion has been that a tight deadband MPFR would oversupply the market, set frequency performance exceeding the level technically required by the power system (therefore above what consumers desire), and "saturate the market". Rather than suppliers responding to price incentives for supply of frequency control, they must provide it. Consumers of tight frequency control benefit from the service for free, paid for by existing producers, and because of this, consume more than they would otherwise.

In making the MPFR rule, the AEMC assumed producers would indirectly account for these costs in energy offer prices and entry investment decisions, and all else being equal, energy prices would rise as a result. Proponents of this argument advocate for the MPFR deadband to be widened to allow an "efficient" level to be revealed, possibly set by a standard, and then provided for through an FCAS market.

AEMO considers this narrative to be simplistic for the following reasons:

- Frequency control is more than just primary control; it is untrue there is oversupply of frequency control from imposing a tight primary control deadband.
- Frequency control is about the relationship between controls; primary and secondary controls work together, and you cannot substitute one for the other (discussed further in AEMO's technical paper).
- Effective secondary controls, including the Regulation FCAS cost allocation system, can mitigate and efficiently allocate economic costs from imposing a tight MPFR.

This is best explained by using some generic concepts used in the application of the Regulation FCAS cost allocation system to identify the theoretical effects of mandatory primary control. The theory is not ideal or perfect because, as discussed later in this report, Regulation FCAS is not a market for frequency control and the cost allocation system is neither a market nor a service.

As stated in Section 1.1, reference to "Regulation FCAS cost allocation system" means the existing deployment as distinct from generic causer pays concepts also considered in this report. This is an important distinction which should be recognised when interpreting this discussion paper.

Nevertheless, generic causer pays concepts are useful because they readily apply to the task of investigating the feasibility of new market service and/or an amended Regulation FCAS cost allocation system to incentivise primary frequency control.

2.1.1 Conceptual framework for investigation

Using the concepts behind the Regulation FCAS cost allocation system to investigate the effects of MPFR:

- **Good performers** would be SCADA-measured elements (generators, loads) who provide good AGC dispatch control and whose errors in dispatch are less than the response they provide.
- **Bad performers** would be SCADA-measured elements who provide poor dispatch control, add to forecast inaccuracy, and whose errors in dispatch are more than response they provide (if they provide any at all).
- **Residual** would be all the non-measured elements that are forecast by AEMO in the dispatch systems. The residual performance opposes the measured elements.

These dynamics are shown conceptually in Figure 1. The good performers are largely limited to Regulation FCAS providers (in green) who are funded by AEMO recovering their enablement costs via the cost allocation system. The funding is indirect because, although AEMO acts as an exchange, the system has the effect of AEMO paying in one currency (Regulation FCAS) and receiving in another (Contribution Factors). The bad performers and residual are shown in red and pay into the Regulation FCAS cost allocation system, dubbed "causer pays" in the figure.

In Figure 1, frequency performance is presented using charts from Dr Undrill's simulations[9] showing the case of secondary control operating without primary control during a load ramp. Frequency is not controlled close to 50 Hz and moves rapidly between the edges of the Normal Operating Frequency Band (NOFB), until settling then moving again. This provides a "tabletop" distribution around 50 Hz. In the example, there is no primary control to slow changes in frequency. This case, proved by a simulation, is very similar to how the NEM operated prior to tight MPFR.

AEMO's Technical White Paper explores the interactions between primary and secondary control in more detail, and describes NEM frequency performance prior to and following the implementation of tight MPFR. This includes the attempts to correct frequency performance through changes to automatic generation control (AGC) and use of Regulation FCAS volumes. These actions were ineffective when not combined with near universal narrow band responsiveness to system frequency.

Based on the 4-second sample rate currently used for SCADA metering of power system plant, the assessment of good and bad plant performance can change every 4 seconds; however, it is worth noting the following:

- Residual and bad performers are effectively "consumers" of frequency control services, in a general sense.
  - Unmeasured residual elements, including forecasts made for them, are not controlled, and neither exposed to the incentive nor able to respond to correct frequency.
    - If frequency performance is worse than the residual would want, which is to say the standard is not being met, then these residual consumers are facing a loss – their demand is not being met.
  - The poor performers are only separated from the residual because they are measured.
    - Frequency performance is acceptable to the poor performers (because otherwise they would improve their performance) and their marginal benefit of poor performance exceeds their marginal cost.
  - Poor frequency control may be said to be analogous to residual consumers paying a subsidy to poor performers.

[9] Dr. John Undrill, Notes on frequency control for the Australian Energy Market Operator, 5 August 2019

- The subsidy is shown with frequency being largely uncontrolled in the NOFB and is payable by residual consumers to the bad performers, who being subject to the Regulation FCAS cost allocation system incentive could choose to perform better, but do not.

- Good performers are effectively "producers" of frequency control services in a general sense.
  - This is evidenced by measured performance.
  - If frequency performance is poor, good performers are too few. This would be because the marginal benefit of improving performance does not exceed the marginal cost.
    - For example, if they are not being paid to improve the frequency, as is the case with the existing Regulation FCAS cost allocation system. Therefore, only the Regulation FCAS providers are shaded green.

Figure 1 Conceptual investigation – system without tight MPFR

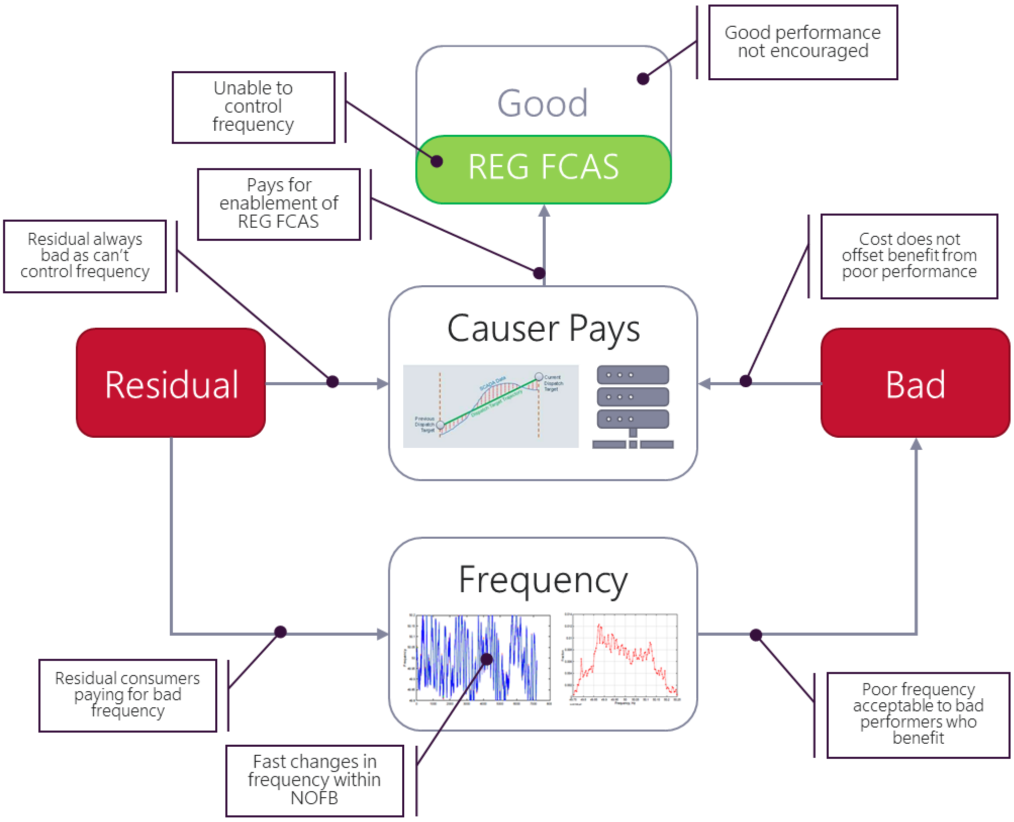


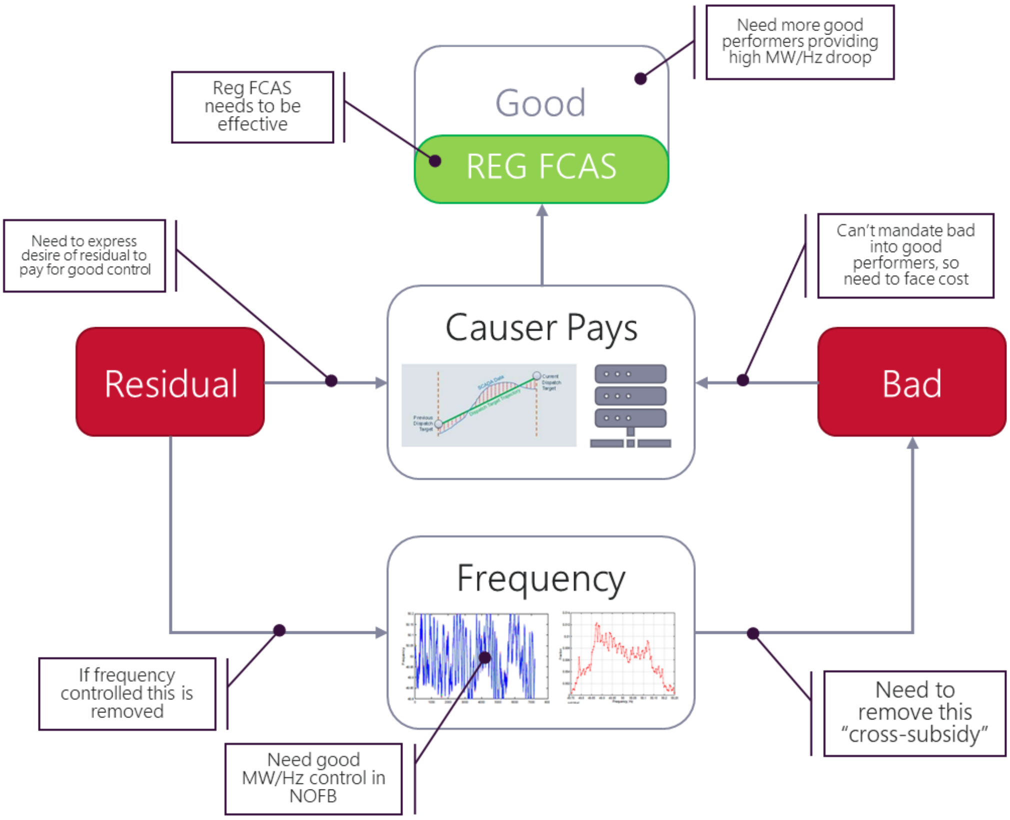
Figure 2 provides an indication of the problems to be solved by any new framework There are both technical power system control and incentive elements to the problem.

The Technical White Paper has explained the need for:

- A high aggregate frequency responsiveness (droop response) across the power system to minimise changes in frequency and to allow secondary controls to effectively restore the energy balance.
- Control throughout the NOFB. For the purposes of this paper, the need for control throughout the NOFB can be taken as an expression of the residual consumers' desire for good frequency control, or to put it another way, a desire to stop suffering poor control.

Figure 2 also shows there needs to be a base of good performers providing a high frequency responsiveness, in aggregate droop response, and that bad performers will still exist but should be discouraged through correcting incentives.

Figure 2 Conceptual investigation – elements of the problem



This paper will investigate how to solve these problems, including whether it is more efficient to instituting control through tight MPFR and then devise improved incentive arrangements, or incentives can be used to institute control.

It should also be recognised that primary and secondary controls are different things, doing different jobs, yet if one does not do its job properly this will affect the performance of the other. AEMO therefore considers it sensible to improve AGC Regulation FCAS to minimise primary response, and to improve the Regulation FCAS cost allocation system to better incentivise good control by rewarding any primary response that is provided.

3. Defining the concepts

This section will explain why Regulation FCAS and its existing cost allocation system do not constitute a market for frequency control, but is instead a reserve and redispatch service with a cost allocation mechanism. The central control is through specifying requirements and services and directly controlling units via AGC to assist in correcting frequency.

It will introduce Frequency Deviation Pricing (FDP) and characterise this as an approach which attempts to approximate frequency control more like a market by measuring and pricing deviations, yet noting it retains the element of central control through a pricing estimate.

It also characterises a possible new market service for primary frequency response, (PFR-FCAS) premised on Regulation FCAS. PFR-FCAS could also have a cost allocation system like the existing Regulation FCAS.

It is possible to combine elements of these concepts – for example, by introducing payments for performance into the existing Regulation FCAS cost allocations system, making it "double sided", and this may be combined with a dispatched market service like Regulation FCAS. As explored further in this paper, the cost allocation may itself form some kind of FDP should it use 4-second performance data to pay for performance.

The distinctions made in this section should be taken as extremes to assist evaluating options in the next section, and need not constrain any final recommendations.

3.1 Is there a market for frequency control?

The NEM attempts to buy frequency control through spot markets. The purpose of using a spot market is to efficiently allocate resources, reduce costs, and stimulate investment.

A market would typically have buyers and sellers who voluntarily trade between themselves. This is impossible without some form of direct regulation over the terms of trade and establishment of an intermediary. The FCAS arrangements in the NER create direct regulations for frequency control, to establish a service for the provision of the frequency control services (where participants must sell) and cost allocation processes (where participants buy).

AEMO does not buy frequency control directly; instead, frequency control is an outcome from the purchase of numerous services, provided under various allowable specifications and enabled by performance standards and control systems. This means that although there are series of FCAS services, there is no direct "market" for frequency control. As noted in the AEMO Technical White Paper, the FCAS arrangements procure frequency responsive reserves. The provision of sufficient frequency responsive plant is a separate characteristic that is necessary for effective "control" of power system frequency

3.2 FCAS in the NEM

FCAS markets operate with a central agent (AEMO) as a buyer, setting a MW reserve requirement, then "enabling" units in security-constrained economic dispatch deliver that requirement every dispatch interval. Each FCAS service has a specification, registration, and compliance requirement where the service specified is not control of frequency directly, but the allocation of capacity reserved to respond to a given change in frequency or frequency trigger. The most relevant service for this paper is Regulation FCAS, where suppliers are enabled for a MW quantity and then "re-dispatched" within the dispatch interval.

AEMO must ensure it procures an appropriate mix of FCAS reserves to maintain frequency within the contingency band and meet the frequency operating standard for operation in the normal operating frequency band (NOFB).

It is possible to institute a market for FCAS reserves within the energy market dispatch because the Regulation FCAS and Contingency FCAS reserve requirements (quantities of MW capacity) are mutually exclusive with energy, so can be co-optimised with it. Bid quantities and offer prices enable these MW reserve requirements to be represented as constraints imposing costs in security-constrained economic dispatch. The change in costs is known as the marginal value of the constraint and is derived from the requirement for economic dispatch to reserve a quantity of FCAS.

Prices for FCAS can be set as the sum of the marginal value of FCAS requirements for the relevant service for the applicable region. The marginal value of the requirement is affected by the FCAS offers of providers decreasing the dispatch "objective function" (making it more costly). With the imposition of the constraint, the objective function includes meeting all requirements for energy and FCAS and is more expensive. This means both energy and FCAS offers can, fully or in part, affect the price of these services.

The **requirement cost** in each dispatch interval is equal to the MW quantity reserved or "enabled" multiplied by the marginal value of the constraint.

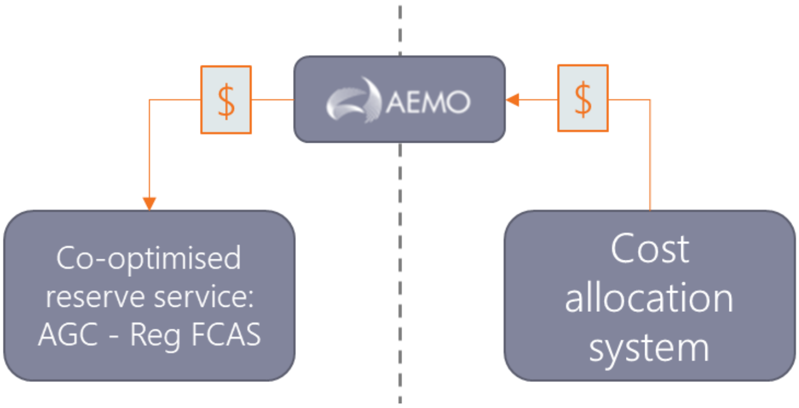
3.3 Regulation FCAS cost allocation system

Figure 3 illustrates Regulation FCAS and its existing cost allocation mechanism, colloquially described as "causer pays", with AEMO centrally managing frequency control. Under this arrangement, frequency control is not achieved through the action of regulation FCAS alone. Frequency control is related to the combined interaction of multiple elements, including:

- The process for the dispatch of generation capacity to meet forecast demand (and errors therein).
- Continuous action of frequency responsive plant that provide narrow band primary frequency response.
- The action of plant enabled to provide regulation services responding to centralised control signals via the AGC system) within a dispatch interval.

This means Regulation FCAS is therefore a "reserve and redispatch" mechanism and not a market for frequency control.

Figure 3 Regulation FCAS and its existing cost allocation mechanism



On the other side, the Regulation FCAS cost allocation mechanism does not constitute a market for frequency control in itself – it simply allocates the requirement costs of Regulation FCAS. Importantly, by not charging "causers" directly in terms of units of Regulating FCAS, it does not make a "market" for the Regulation FCAS either (because trading is not of the same commodity, so there is not really a market). Nevertheless, the NER[10] expresses the principle that the costs of regulation services should be allocated, in a way that reflects participant contributions to the need for the service. It is for this reason the cost allocation system uses the regulating FCAS signal "Frequency Indicator" to assess performance.

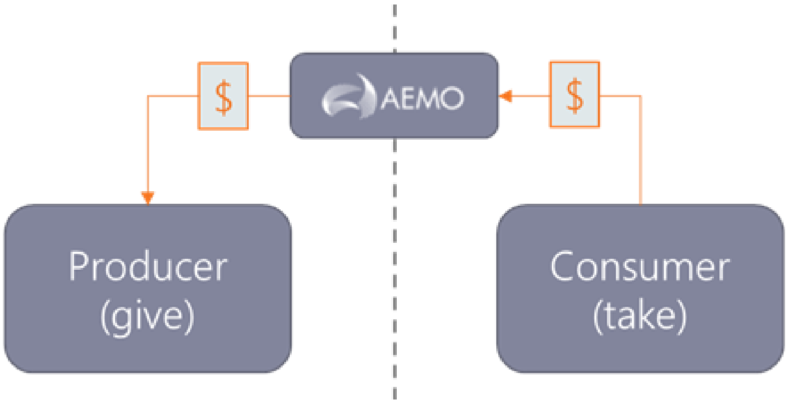
In summary, the existing combination of Regulation FCAS and its cost allocation system is neither a market for frequency control nor a market for Regulation FCAS, (participants do not buy and sell regulation FCAS between one another). It constitutes a reserve and redispatch service with a cost allocation mechanism.

3.4 Frequency Deviation Pricing (FDP)

Unlike Regulation FCAS, FDP does not need MW "enablement" requirements to be imposed in security constrained economic dispatch to derive a price. This is because FDP applies a known price scale to a performance measure, like Hz error which providers respond to by delivering the necessary response or conversely minimising dispatch errors that may cause a need for frequency services.

[10] Clause 3.15.6A(k)(1)

Figure 4 Frequency Deviation Pricing



FDP establishes a mechanism for the sale and purchase of deviations and is like a market in these, where the cost of the deviation is pegged to frequency. Because the price scale is related to frequency, FDP assumes measurement and pricing of deviations will allow for control of frequency, through the pricing function and not by a dispatched market service like Regulation FCAS. It is for this reason there is no direct control of reserves, redispatch, and no requirement cost to recover. Unmeasured elements can be accounted for through a control philosophy, in deriving the price incentive. The premise is that frequency control can be approximated into a price scalar or weighting, instituting a market for frequency control, paid for in deviations multiplied by a performance scale.

For these reasons, FDP can be said to approximate frequency control more like a market by measuring and pricing deviations. This is a fundamentally different approach to Regulation FCAS and its cost allocation mechanism.

That the NER uses different arrangements for procurement and cost allocation implies Regulation FCAS is a public good. The cost allocation methods attempt to recover costs reasonably effectively, yet still recognise the consumption of these services is not readily identifiable or excludable. It is not the purpose of this paper to challenge this premise, however AEMO notes a 'pure' concept of FDP attempts to make frequency control more like a private good by measuring dispatch deviations and creating payments between them, a bit like trading imbalances in electricity consumption.

Whether the measuring of deviations and instituting credits and debit payments for them can be a direct substitute for frequency control services is an interesting question, and one this paper touches on. The question is whether the Regulation FCAS cost allocation system should remain simply a cost allocation procedure or more like a market for frequency control.

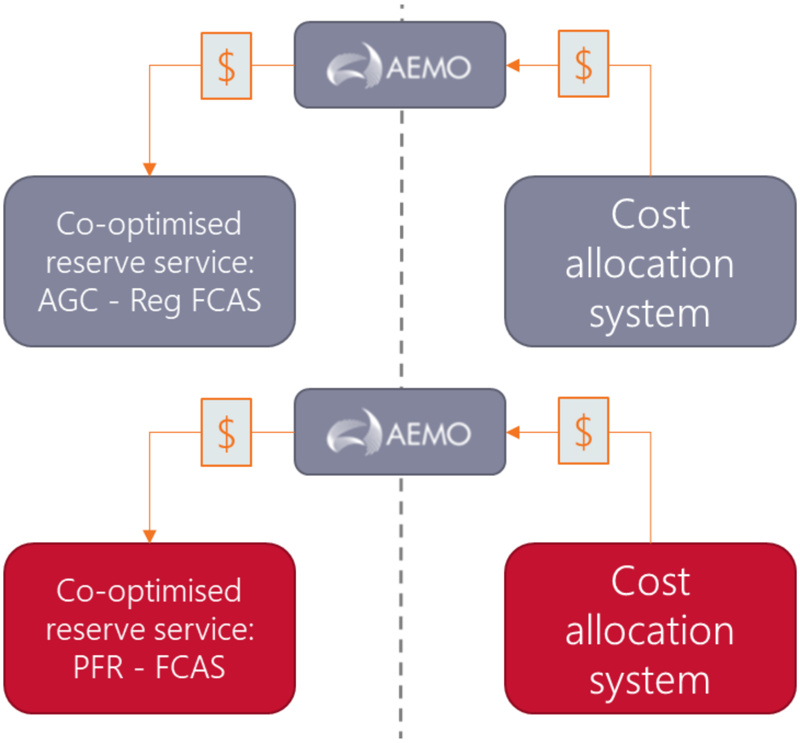
3.5 A new FCAS for primary frequency response – PFR-FCAS

A new dispatched market could be established for primary control with another cost allocation system. The application of the concept is shown in Figure 5.

Existing Regulation FCAS and its cost allocation system would remain unchanged. This would allow a further co-optimised market service, known as Primary Frequency Response – FCAS (PFR-FCAS) to be dispatched and paid for, which may necessitate a new, separate cost allocation mechanism.

The new mechanism is described as causer pays for primary control, and would probably be a cost recovery mechanism and not an incentive for primary control (because this is incentivised by the PFR-FCAS itself).

Figure 5 Primary service PFR-FCAS alongside Regulation FCAS



The premises behind the two services are the same. Each service is not the purchasing of frequency control, but a technical service that contributes to the outcome of good frequency control. The cost allocation mechanism for primary control is just that – an allocation mechanism – and not a market for primary control.

The AEMC asked AEMO to investigate how a PFR-FCAS could be implemented. AEMO provides its assessment in Appendix A1.

3.6 "Double-siding" a cost allocation system

The cost allocation systems referred to in sections 3.3 and 3.5 may also include payments for measured performance that is deemed "good". This performance is simply measured as opposing the "bad" performance. The existing Regulation FCAS cost allocation system does not directly credit good performance unless a unit is part of a greater participant portfolio where there is offsetting bad performance available.

Introducing both debit and credit transactions would mean the cost allocation system becomes double-sided. If this were to be done for the Regulation FCAS cost allocation system, the credits would be valued directly against the debits, which recover a share of Regulation FCAS costs. This means a credit for good performance is valued using Regulation FCAS. This has been referred to as Double-Sided Causer Pays (DSCP) by the AEMC[11] and adopts the same assumptions of the Regulation FCAS cost allocation system in that it is neither a market for frequency control nor a direct market for Regulation FCAS.

Although there are variations that could strive for different purposes, for the purposes of this report, DSCP is unlike FDP because it does not try to institute control directly through price.

[11] P80 Option F: Performance based PFR incentives – using regulation FCAS contribution factors (double-sided causer pays) - AEMC, Frequency control rule changes, 17 December 2020.

4. Evaluating the options

The AEMC asked AEMO to consider a series of options for incentivising primary control, as summarised below. This section builds on discussions and materials prepared by the AEMC during the preparation of this document. Pathways and sub-options are as defined by the AEMC project team, set out in Table 1.

AEMO has considered the options across three different "pathways" based on a tight, wider, or no MPFR deadband.

Table 1 List of AEMC policy pathways and incentivisation options for enduring PFR arrangements

Pathway	Option	Shorthand
1 tight MPFR **OR** 2 mod/wide MPFR	a. No additional arrangements – (MPFR plus existing FCAS only)	Status Quo
	b. MPFR + improved pricing arrangements (FDP/DSCP or regulated pricing)	Paying for performance
	c. MPFR + PFR FCAS	Dispatched Market
	d. MPFR + PFR FCAS + improved pricing arrangements (FDP/DSCP or regulated pricing)	Both

As noted in AEMO's Technical White Paper, the options differ materially from a system design point of view and in terms of their ability to provide effective frequency control under normal operating conditions. This means that:

- Tight deadband pathways provide an effective control base, with the different options focussed on improving economic efficiency of frequency control indirectly through incentives.
- Moderate/wide deadband pathways start from no control base, with incentivisation options aiming to restore control within the normal operation band.

"Pathway 3" involved removing the mandatory requirement and has not been considered. This is because this assessment pertains to incentivising frequency response under normal operation. It is not concerned with a choice of deadband wider than the normal operating frequency band (+/-0.15 Hz) or the contingency band (+/-0.5 Hz). Apart from being wider than +/-0.15 Hz, the exact choice of the deadband for Pathway 2 is unimportant for this document.

The AEMC presented some nuances between the options: for example, options 1a and 2b discuss the option of FDP, DSCP, or regulated pricing, and AEMO has simplified this to "performance payments". This allows discussion to focus on which performance payment option is appropriate for the chosen deadband setting, because, as will be explained, some options are unsuitable for different deadband options.

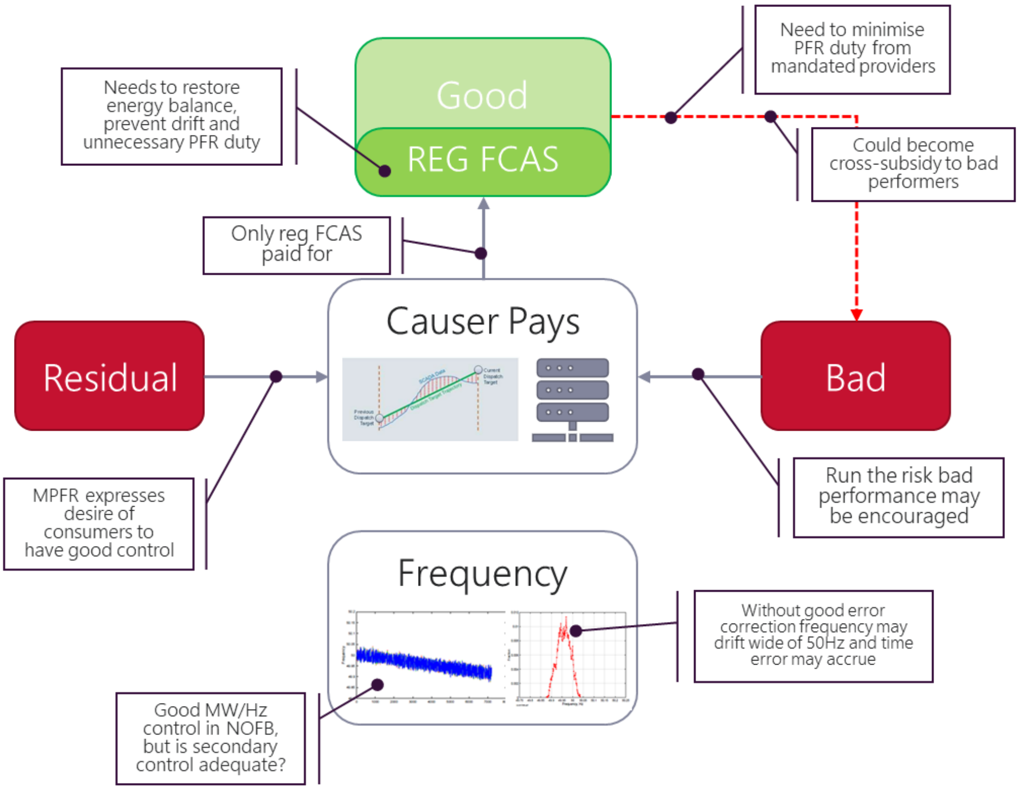
This section applies the conceptual investigation in Figure 1 to assess options 1a, 1b and 2c. The others have not been ignored – detailed assessment of the full list of options is provided in Appendix A2.

4.1.1 Option 1a – tight MPFR only

Option 1a introduces tight MPFR without any additional changes to incentive arrangements, and is evaluated in Figure 6.

The mandatory tight deadband institutes control within the NOFB reflecting AEMO's engineering needs and expressing[12] residual consumers' need for frequency to be controlled. For this reason, the cross-subsidy between the residual and bad performers is removed from the figure.

Figure 6 Evaluation of the effects of Option 1a – tight MPFR



Although frequency performance has improved with high aggregate responsiveness preventing rapid changes in frequency, the figure shows frequency drifting and a tight frequency distribution offset from 50 Hz. The frequency charts are taken from Dr Undrill's simulations and show the case of primary control operating without secondary controls during a load ramp. This does not represent the control that has been achieved with tight MPFR, because in practice the NEM operates with secondary controls.

In the example there is frequency drift, because there is no secondary control to restore the energy balance and preventing time error accumulating, thus primary control response acts in proportion to the change in frequency.

This is an extreme case, proved by a simulation, and is simply used to indicate how primary control is affected by the effectiveness of secondary controls: remove them, and more and more primary response is required. It is for this reason the figure includes a new red dotted line indicating a potential cross-subsidy from good performers to bad performers in the form of excessive primary response. With the Regulation FCAS cost allocation system, good performance or "deviations", irrespective of how they are provided, are not paid for (unless they offset poor performance within a participant portfolio).

For the same reason, imposing tight deadband MPFR would not convert all bad performers into good ones[13]; the bad performers remain are as they were in the earlier figures, continuing with their level of frequency control and bad performance, because they can profit from bad performance. The question here is whether

[12] In AEMO's opinion this is the case – frequency needs to be controlled within the NOFB.

[13] Tight deadband droop response does not ensure good dispatch control – the unit may have other reasons, such as available primary resource, boiler control or pressure issues, or milling throughput. problems that cause errors.

the existing Regulation FCAS cost allocation system fails to discourage poor performance by allocating costs to those that caused a need for them.

Because the Regulation FCAS cost allocation system did not seem to discourage poor performance (or encourage good performance) prior to implementing tight MPFR, (because frequency control was poor during this period), it may need to be improved. AEMO considers the incentive arrangements for plant performance that helps to control system frequency are inadequate, as demonstrated by the need to instate tight MPFR. AEMO also notes tight MPFR does not correct this, which is a statement generally supported by the AEMC in previous publications.

This indicates that tight MPFR resolves the control element of the problem, explained in Figure 2, if the dispatch, AGC, and regulation FCAS operate satisfactorily, but does not alone address any poor incentives, so the incentives element of the problem may remain. AEMO has not assessed the materiality of any misaligned incentives. Unresolved, this may encourage bad performers to worsen and for good performers under tight MPFR arrangements to frustrate their compliance requirements, possibly by amending other control or operating schemes, like restricting steam flow.

Additionally, widening the MPFR deadband, reducing control and increasing the allowable frequency deviation to some perceived "efficient level", would affect who pays a subsidy, but not its existence. This is consistent with the Dr Undrill's advice recommending that there was no room to manoeuvre on the deadband setting, and also highlighting the need to improve trading incentives and penalties.

As highlighted in the Technical White Paper, it should also be recognised that primary and secondary controls are different things, doing different jobs, yet if one doesn't do its job properly this will affect the performance of the other. It is sensible to improve AGC Regulation FCAS to minimise primary response and to improve the Regulation FCAS cost allocation system, so it improves incentives for good control and rewards any primary response that is provided.

4.1.2 Option 1b – tight MPFR and paying for performance

Option 1b expands Option 1a, with both tight MPFR and improvements to incentive arrangements, evaluated in Figure 7. Similarly, tight MPFR provides control, in line with residual consumers need for good control through high aggregate frequency responsiveness in MW/Hz.

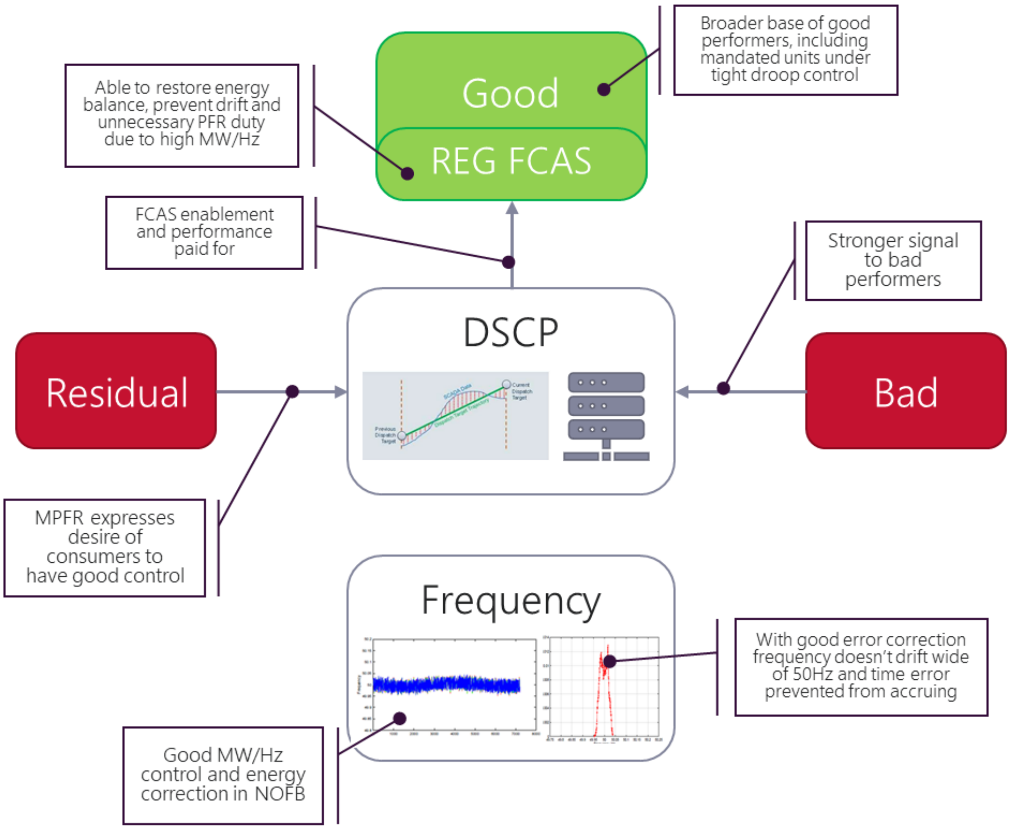
Under this option, frequency performance has improved, with high aggregate droop preventing rapid changes in frequency, with the figure showing frequency held close to 50 Hz with a tight distribution around 50 Hz. The frequency charts are taken from Dr Undrill's simulations and show the case of primary control operating with secondary controls during a load ramp.

In the example, there are no rapid changes of frequency and no frequency drift, because primary control reduces the speed of frequency changing in the NOFB and secondary control restores the energy balance and prevents time error accumulating. This is an ideal case, proved by a simulation, demonstrating how primary control and secondary control work together and perform different roles. It is for this reason the frequency box is not linked to any other and provides no cross-subsidy in the form of poor frequency control.

While primary response duty is mitigated by the high aggregate droop resulting in a very small Hz deviation and effective secondary controls, the figure also suggests any possible cross-subsidy in the form of primary response could be compensated for by the payments for performance inherent in a double-sided causer pays system. Payments can be made to all the good performers, not simply those enabled for Regulation FCAS. This is important because, although one would expect the Regulation FCAS units to provide majority of error correction and for the system to be focused on performance against a slower moving secondary control error, rather than Hz error, if the error is significant enough to cause enough of a Hz deviation to result in a material contribution from units mandated to do so under tight MPFR, then these units will be rewarded for doing so.

This payment for positive performance also provides the opportunity to improve the incentive signal for the bad performers, so they do not profit from worsening their performance.

Figure 7 Evaluation of the effects of Option 1b – tight MPFR and payments for performance



This assessment suggests that while tight MPFR resolves the control element of the problem, the incentives element of the problem, arising from poor incentives in the existing causer pays system, can be improved through introducing payments for performance and generally improving the incentives it provides. Again, this is consistent with the advice from Dr Undrill, who said there was no room to manoeuvre on the deadband setting but did highlight the need to improve trading incentives and penalties.

4.1.3 Option 2c – wide MPFR and PFR-FCAS

Option 2c considers the widening of the MPFR deadband supported by a new PFR-FCAS service, evaluated in Figure 8. This uses the same conceptual framework, this time reverting to a single-sided cost allocation system, which notionally recovers amounts for both Regulation FCAS and a new PFR-FCAS service. This is because Option 2d includes payments for performance, so excluding these payments allows investigation of a new market service, PFR-FCAS. Whether there is a separate cost allocation system for the two services is unimportant for this evaluation.

Under this option, frequency performance remains poor, because there is no longer a high aggregate droop preventing rapid changes in frequency within the NOFB. The frequency charts are taken from Dr Undrill's simulations and show the case of a system operating without primary control during a load ramp. This selection is not a fair comparison, because the units enabled to provide primary response should act to control changes in frequency to some extent. It does highlight the impact of PFR-FCAS in reducing the level of droop response from a maximal, ubiquitous control element to a minimal, rationed market element.

The very intent of the PFR-FCAS service is to restrict the aggregate amount of narrowband primary control to some predetermined level, increasing the response from select units. Appendix A1 discusses how a PFR-FCAS may work and the relationship between aggregate frequency responsiveness (control), allowable Hz error, and primary response (work) at a system and unit level. The problem with trying to concentrate primary response to the cheapest units more efficiently is that this either requires a reduction in aggregate frequency responsiveness (control) by allowing Hz error or very aggressive droop response on fewer units, which may be undesirable and potentially infeasible in the NEM (discussed further in AEMO's Technical White Paper). Appendix Error! Reference source not found. also highlights that dispatch is an optimisation of energy and FCAS requirements and does not include a further objective, which to ensure a minimum aggregate frequency responsiveness.

It may be technically feasible to:

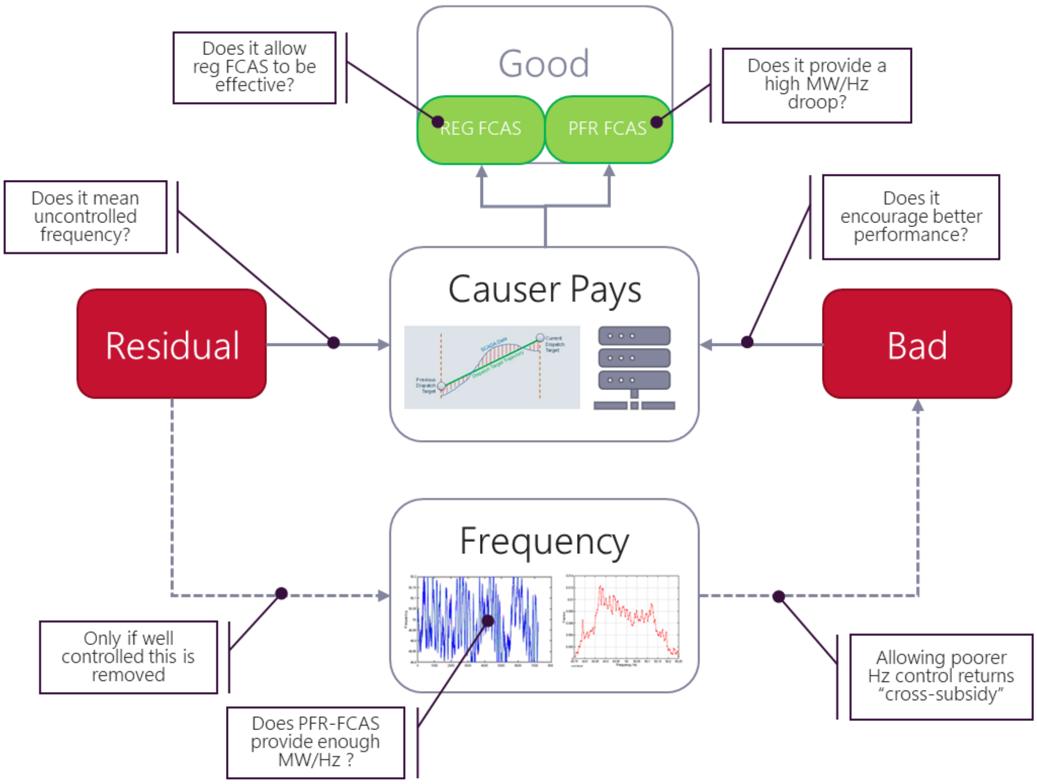
- Define a frequency standard for normal operation (as outlined in AEMO's suggested amendment to the Frequency Operating Standard in the Technical White Paper).
- Define the service characteristics required to meet it in MW/Hz, seconds, and MW.
- Establish arrangements for the procurement of plant.

Notwithstanding this, more work would be needed to establish whether a service can be included in security constrained economic dispatch optimisation.

AEMO considers lessening the level of control would reintroduce the link in the frequency box between the residual and the bad performers; by deliberately allowing less control in the normal operating band, a potential cross-subsidy may exist in the form of poor frequency control. For reasons given in Appendix A1, AEMO considers PFR-FCAS is unlikely to fully resolve the control element of the problem.

This means PFR-FCAS also fails to resolve the incentive element of the problem, because it does not provide a level of control desired by residual consumers. The only instance when PFR-FCAS would provide more control than tight MPFR would be if there is a scarcity of reserves (which have primary droop control). It should be noted it is not the procurement of reserves itself that provides control; rather, it is the institution of a high aggregate frequency responsiveness provided for by tight MPFR. In this example, under nearly all conditions the procurement of reserves adds nothing, bar reducing the available droop to the procured level, because all other reserves are not required to provide droop response for normal operation.

Figure 8 Evaluation of the effects of Option 2c – wide MPFR and PFR-FCAS



It must be noted the comments above are comparing a new dispatch market to tight MPFR – this is because the option includes widening the deadband to at least +/-0.15 Hz. In this option, a new dispatched market for primary response must provide as much control as tight MPFR, which it is unlikely to do. As discussed in Section 4.2 and Appendices A1.1.6, A2.1.3 of this paper, the usefulness of a PFR-FCAS may be to supplement (rather than replace) tight MPFR and improved incentives, which is Option 1d.

4.2 Summary of options

This section has conceptually investigated the effects of three of the AEMC's eight proposed options. It has highlighted how tight MPFR alone is a "partial solution", as recognised by the AEMC when making the MPFR rule. Tight MPFR resolves the control element of the problem, subject to secondary control working effectively (which it should), yet does not resolve the incentives element of the problem explained in Section 2.

Removing tight deadband MPFR reinstates the control problem, and then requires another service to resolve both the control element and incentive element of the problem. AEMO has highlighted that PFR-FCAS may not sufficiently resolve either element of the problem, and seems to be premised on lessening of control through reducing the availability of PFR and reducing the aggregate droop response on the system. Rather than lessening control to some "efficient" level, it appears any lessening of aggregate droop response from that available under tight MPFR is accepting poorer control for residual consumers to the benefit of bad performers. These drawbacks of PFR-FCAS would apply to any proposal that does not include tight deadband MPFR, for example wide deadband FDP.

As discussed in the Technical White Paper, AEMO considers primary control cannot be economised through a market service. There is a distinction between control and response, where the system needs lots of primary control (available droop response MW/Hz, or aggregate frequency responsiveness), but not much primary response (energy response provided MWh). This is because in a system with a high aggregate frequency responsiveness, the frequency deviation is small and because primary response is in proportion to frequency, this is minimised. A system where units are providing significant primary response is likely to have little MW/Hz control or is responding to a contingency.

Recognising primary response is provided by units on tight MPFR, AEMO suggests this can be minimised by the system-wide, ubiquitous imposition of tight MPFR, leading to good control of frequency and allowing good correction of errors through AGC regulation and dispatch. A system with good control minimises the work (response) of both primary and secondary controls, where dispatch errors do not lead to significant Hz error by tight MPFR and corrected by effective secondary controls across the five minutes.

Most importantly for this paper, AEMO has suggested incentives could be improved with the dual purpose to:

- Credit good performance, including any primary response that does occur from mandated units, and
- Impose better incentives on "causers", with the effect of minimising primary and secondary response by improving dispatch.

It has been suggested that AEMO has insisted on too much primary control and incrementally adding further droop response after the first tranches will have minimal improvement on frequency. This misses the point made above, that the extra primary control from ubiquitous tight MPFR, as opposed to a section of the fleet, minimises Hz deviation ever more slightly but spreads this response across all units providing tight MPFR, reducing duty on individual units to a low level – but only if secondary control is effectively correcting the error and incentives encourage good dispatch performance to reduce the error.

In the near term, extending MPFR to all providers, increasing control, would further reduce the effect of the mandatory requirement on individual units. This is about more effectively meeting frequency performance outcomes, rather than seeking better frequency performance. In the long term, it ensures all new technologies are effective at contributing to the control of frequency, again further reducing the effect of the mandatory requirement on individual units.

Seen in this light, AEMO suggests opportunity for economising primary control within +/-0.15 Hz rapidly diminishes because the performance is achieved without significant primary response costs, or excessive use of generator capacity.

As reinstating the control problem is not an acceptable power system outcome, AEMO recommends resolving the incentives element of the problem by improving or replacing the existing causer pays system for Regulation FCAS.

It is important to note that all options with tight MPFR resolve the control element of the problem, and the incentives element may be mitigated by introducing payments for performance and improving the Regulation FCAS cost allocation system. Widening the MPFR appears to reinstate the control problem, and may be problematic because AEMO doubts this can be overcome by procuring capacity reserves similar to existing FCAS deployment (like PFR-FCAS), nor through improving incentives through FDP. On its own, with a wide deadband, PFR-FCAS may not resolve either element of the problem very well.

Figure 9 presents a summary of the options under consideration in the AEMC's policy pathways 1 and 2, building on the conceptual framework and discussion above. Further consideration of each option is provided in in Appendix A2.

Figure 9 Summary of options

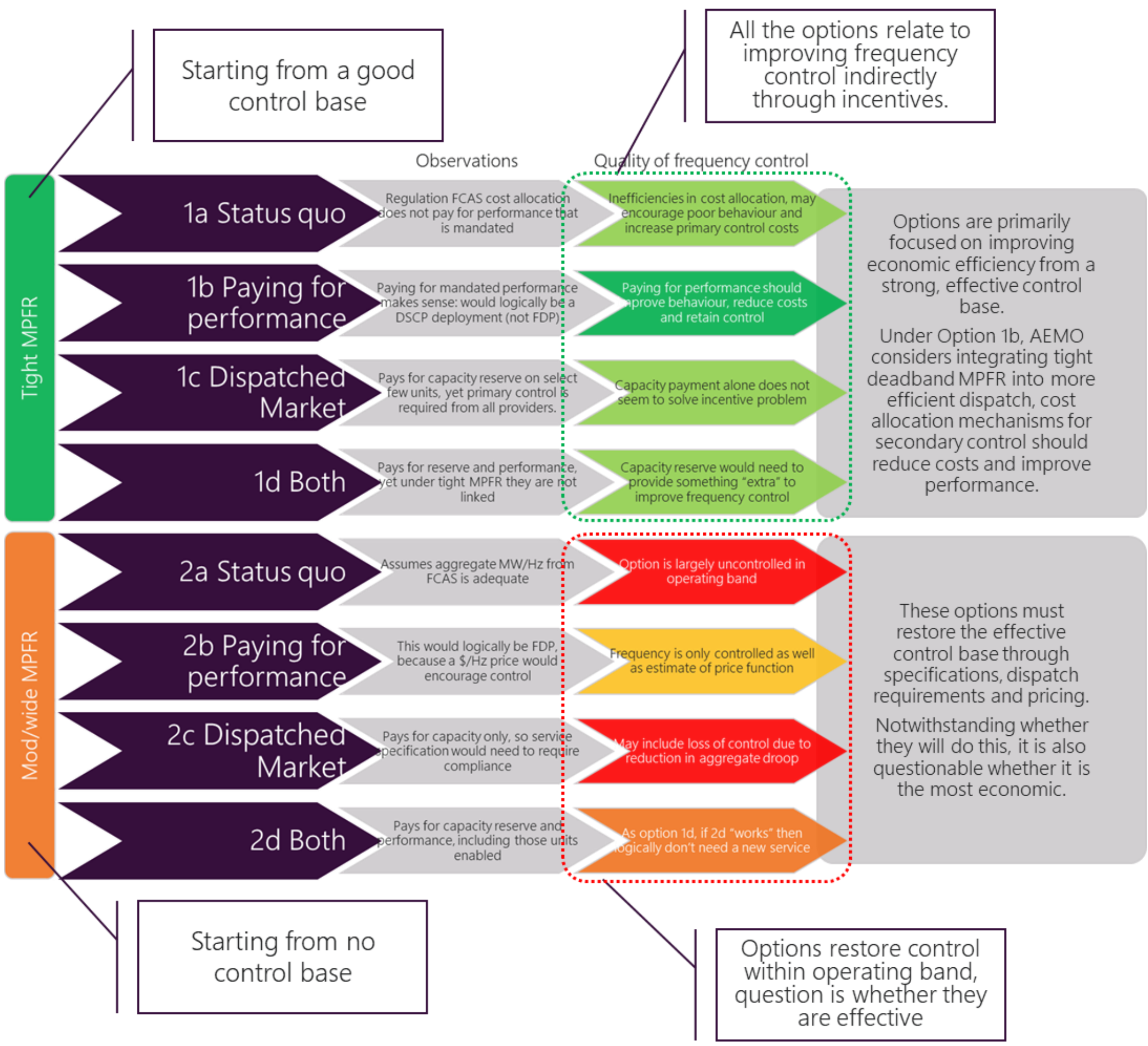


Figure 9 highlights:

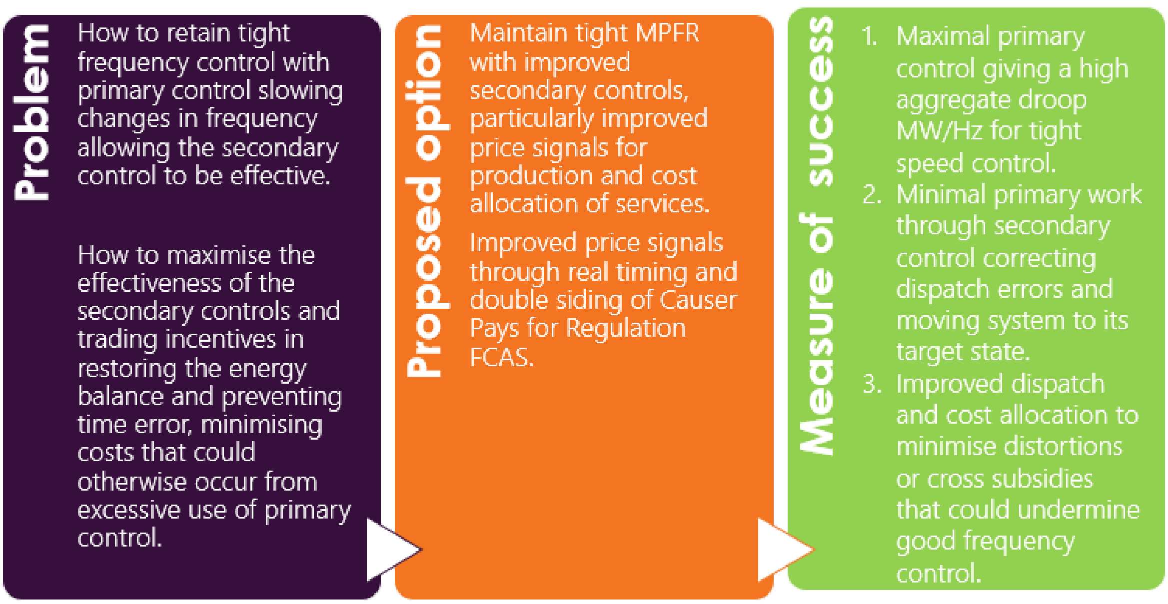
- How tight MPFR and effective secondary controls result in effective frequency control outcomes. All options under Pathway 1 (1a-d) start from the position of good control, the key consideration then being economic efficiency – which option best aligns incentives for provision by minimising cross-subsidies and behavioural distortions:
  - Options 1a and c are not recommended because they unnecessarily increase costs and, to some extent at least, adversely affect frequency through poor dispatch and pricing incentives.
  - Option 1d requires an evaluation of whether the addition of a dispatched market may be useful with a tight MPFR deadband. Appendices A1.1.6 and A2.1.4 provide further discussion on the potential validity of a dispatched service with tight MPFR under future power system conditions.
  - Option 1b is AEMO's preferred approach as it incentivises behaviour aligned with frequency control objectives, by rewarding good performance, reducing costs, and resulting in more efficient dispatch.
- AEMO does not recommend any of the options in Pathway 2, as they reinstate the control problem under normal operating conditions. The feasibility of restoring effective control through complex specifications, dispatch requirements and pricing is questionable – and not guaranteed to provide the same or improved frequency control or economic outcomes compared to the preferred option.

5. Recommended option

5.1 Way forward

Figure 10 summarises how AEMO has assessed the problem, a recommended approach, and what constitutes success. The problem is defined in terms of improving secondary controls – their effectiveness, pricing, and cost allocation – but it should also be read as rewarding any primary response provided by mandated units. This differs from the premise behind the request for this report, which related to directly pricing and optimising PFR.

Figure 10 High-level way forward



AEMO's Technical White Paper specifies the need for effective primary control, particularly tight Hz control providing high aggregate MW/Hz frequency responsiveness at the system level.

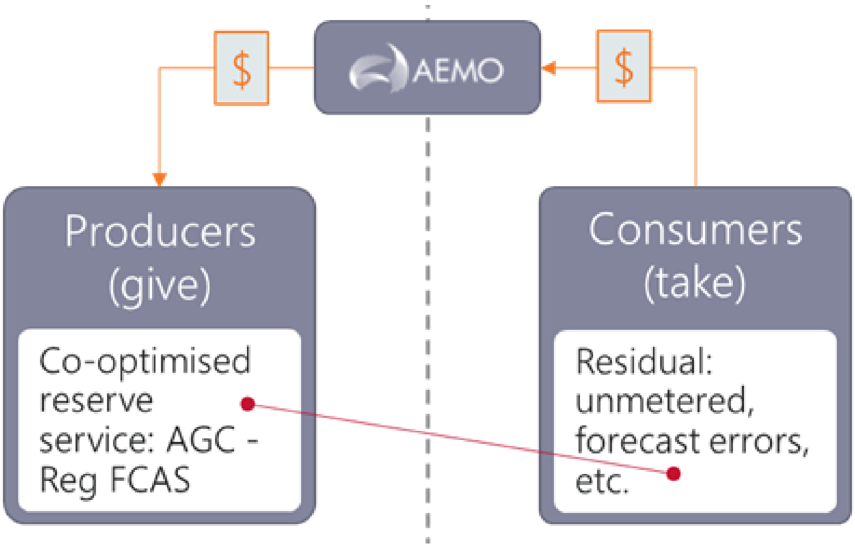
This discussion paper does not support pricing and concentrating primary response through a specific dispatched market, owing to the difficulty of treating aggregate frequency responsiveness to small, incremental changes in frequency as a simple fungible commodity that can be optimised with energy (like FCAS reserves).

Instead, AEMO recommends rewarding mandatory response, but also minimising the need for it, through better dispatch incentives. This means there is no direct need to 'price' primary and secondary control because the control is already specified by the tight MPFR requirement and the AGC system dispatching Regulation FCAS. Because the existing premise behind Regulation FCAS, that it is a redispatch service with a cost allocation system to fund it, can remain, there is no need to create a market directly pricing PFR.

5.2 Preferred approach

Figure 11 presents how the existing Regulation FCAS cost allocation system could be amended.

Figure 11 Preferred approach – 1b tight MPFR with payments for performance



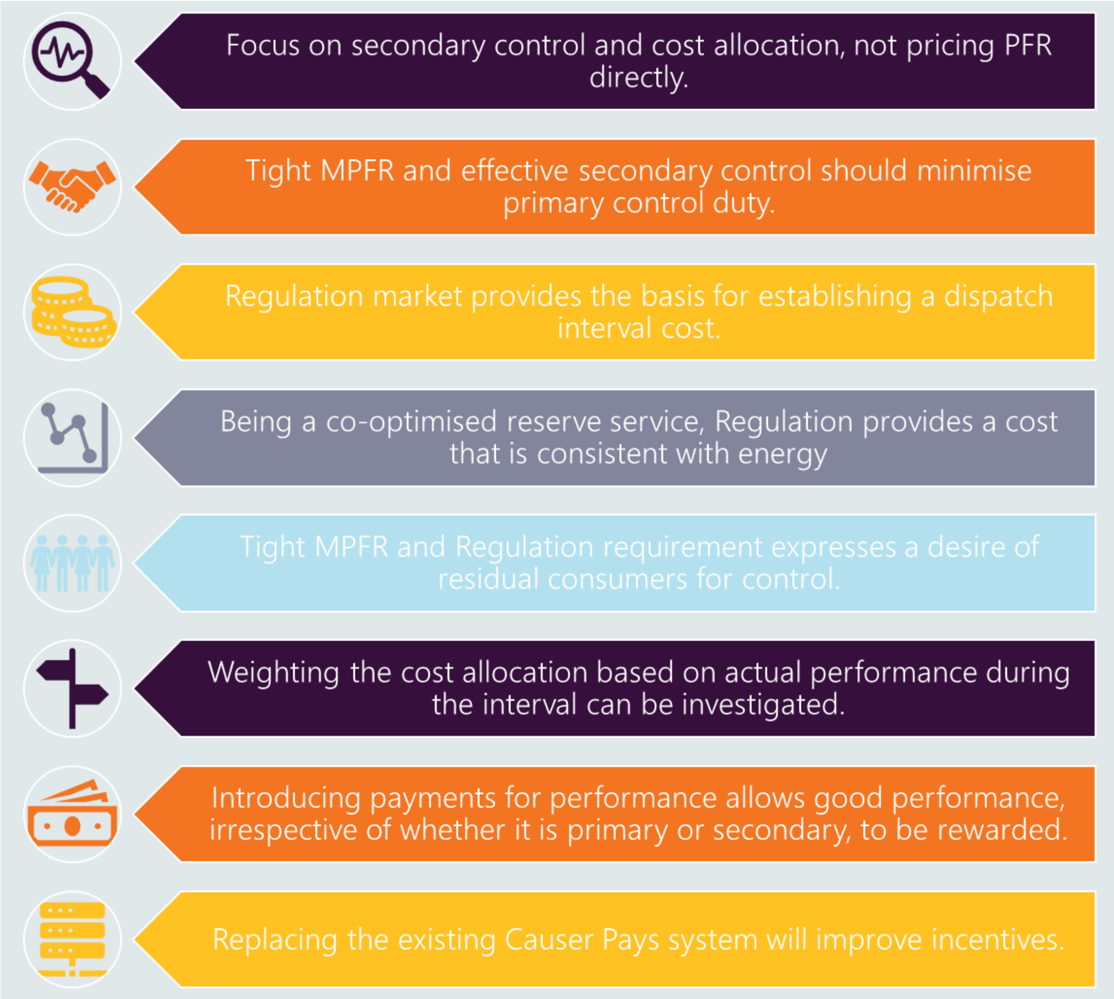
The product for Regulation FCAS would remain reserve and redispatch and would not constitute a direct market for frequency control. The presence of residual elements encourages AEMO to continue to dispatch services, to account for forecast error and variability. Control of frequency remains an outcome from multiple elements, including a tight MPFR deadband which maximises the available aggregate droop for tight control close to 50 Hz.

Because there remains a co-optimised market service, even though there are payments for performance, it remains a cost allocation procedure, and not a market for frequency control. The premise behind paying for positive performance is reflected in Section 4.1.2 above.

Importantly, reserve market requirement costs can be used or scaled to encourage positive performance and to discourage poor performance, thus improving the cost allocation and to a reasonable extent maximising both the effectiveness of secondary control and, in turn, primary controls.

Figure 12 summarises the rationale for the preferred approach.

Figure 12 High-level reasons for the preferred approach



The preferred approach is as follows:

- Tight deadband MPFR, +/-15mHz retained.

Improved Regulation FCAS cost allocation system:

- Performance payments, so double-sided, uncapped – positive performance is paid a value derived from regulation requirement cost.
- Regulation FCAS provides a bid-based market which can be used to "double-side" transactions.
- Real timing the calculation to five minutes sharpens the incentive;
- Regulating FCAS reserves can be set more flexibly with the knowledge there is some stabilising effect from double siding; and
- Performance measure is focused on energy correction for secondary control.

The objective is very tight frequency (Hz) control, minimising primary control duty and maximising secondary control to correct dispatch errors. Further work needs to be conducted on the pricing incentives and performance measure.

For contingencies, noting secondary control cannot arrest frequency, reserves must be procured to provide primary control response, due to the sizeable Hz error.

5.3 Implementation

AEMO provides the following high-level cost estimates for implementing the recommendations from this paper.

The recommendations require a complete redraft of the Regulation FCAS contribution factor procedure and replacement of the obsolete cost allocation system.

The estimate to replace the cost allocation system is $3 million (low), to $5 million (mid), to $8 million (high).

There is significant uncertainty because cost is a function of specification. The specification is unknown and further features may be required, particularly in providing real-time data and calculations to participants. Costs would be confirmed when design is known (after the procedural requirements are agreed and specification complete).

Replacing the cost allocation system requires consulting on a replacement procedure, and design specification, including prototyping. Further development and integration into settlements would also be required.

- Procedure development: at least 9 months.
- Software developments: 18 months.

These estimates are additive, so assuming a Final Determination December 2021, a "go-live" commencement of the NER amendment may provisionally be estimated between March 2024 to June 2024.

Replacement of the cost allocation system is likely to be implemented as part of the delivery of the Energy Security Board's Post 2025 Market Reform program. This is a large program of work that will require significant resources to implement, across AEMO and industry, which could impact the timing of the go-live commencement date for the cost allocation system. Further, the program of Essential System Service reforms is likely to require the uplift of the NEM's dispatch systems.

A1. Primary Frequency Response – FCAS

A1.1 What is a new PFR-FCAS?

In this section, AEMO considers a new dispatched market for primary control as an alternative to tight MPFR. Appendices 34A1.1.6 and A2.1.4 consider the role of a new dispatched market with tight MPFR.

Implementing PFR-FCAS as another FCAS service may require:

- Setting the MPFR to a moderate setting, like the edge of the NOFB band (+/-0.15 Hz).
- Amendment to Market Ancillary Service Specification (MASS) specification to include PFR-FCAS.
- Registration of PRS providers, associated testing, and compliance measures.
- Development of generic constraints to schedule PFR-FCAS requirements.
- Development of constraints to schedule aggregate system droop requirement MW/Hz.
- Changes to the settlements systems and processes.
- The inclusion of include local quantities of PFR-FCAS being enabled in generic constraints, such as thermal limits.

The list provides the basic requirements of any FCAS deployment, although there is additional complexity related to integrating the aggregate frequency responsiveness and droop into security-constrained economic dispatch.

A1.1.1 System level

Energy market dispatch assumes all megawatts are homogenous and will dispatch subject to the bid and technical parameters, including availability, ramp rates, and for FCAS the registered volumes, max and min enablement values, and breakpoints. For some providers, depending on the FCAS "trapezium" and registered volumes, the FCAS dispatch can have an equivalence of more or less than 1 MW.

The current approach is to "set and forget" this through registration of FCAS services, when new suppliers qualify by proving their resources can comply with the MASS. This opposes the approach used for energy market dispatch, where generators can bid ramp rates MW/min in the bid file and provide SCADA ramp rates for use in AGC and regulating FCAS.

It may be prudent to operate within a certain MW per Hz range to control frequency. This could form part of an operating standard. AEMO would then need to introduce a system requirement to maintain a minimum MW/Hz of primary control.

To do this, dispatch would need to be constrained, not just by a requirement for a certain quantity of megawatts (the requirement in the generic FCAS constraint, say 300 MW), but to a minimum MW/Hz droop value.

This means dispatch cannot increase on one unit as opposed to two without either increasing the droop on the one unit or increasing the allowable frequency deviation. The system cannot procure more megawatts from one PFR-FCAS provider than another unless the droop of the unit is more aggressive. This means the available megawatts of PFR-FCAS are not homogenous unless they have the same droop.

This suggests droop, the change output for a change in frequency (maximum 5% under IPFRR), could be a variable within dispatch with units offering a higher droop to be able to sell more megawatts of PFR-FCAS in economic dispatch. A battery could for instance offer 1% droop and provide the response of five other units (subject to capacity constraints), and this could allow PFR-FCAS to concentrate dispatch to that battery.

As discussed in this paper, changing the primary control MW/Hz can affect the performance of the secondary control, therefore an aggregate system droop requirement may be based on an assessment of the requirements for secondary control. It may also suggest there is some optimisation between primary and secondary control, which is incorrect.

Regulation FCAS and Contingency FCAS are requirements that are set independently and are in addition to each other. The same would apply for PFR-FCAS. Local requirements would apply under separation and risk of separation conditions. There may also be some local requirements applied for normal conditions.

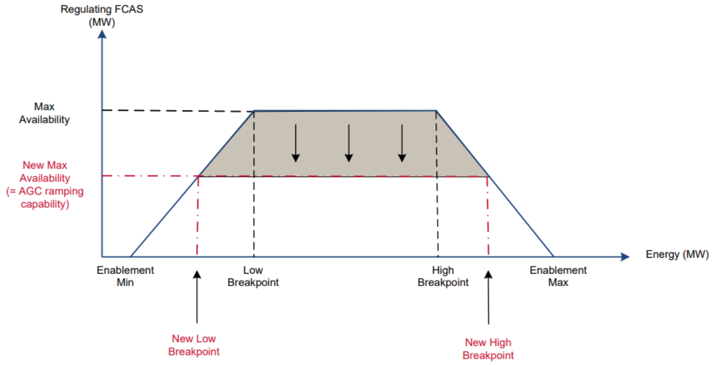
Generic constraints, such as thermal limits and voltage stability, limit the dispatch of generators, typically in response to credible contingencies. There are some constraints that limit regulation enablement in Queensland under high loading conditions of the Queensland New South Wales Interconnector (QNI), or after high utilisation of regulation FCAS in Queensland will reduce interconnector target flows in dispatch. Similar amendments to generic constraints may become prevalent if there are very high local quantities of PFR-FCAS being enabled at an aggressive droop setting at certain locations. This could be managed in the design of the service, offer quantity caps in registration, through generic constraints, or a mix of both.

A1.1.2 Unit level

Units when enabled must operate with a very tight deadband, +/-15 millihertz (mHz), or none. This will be a hard requirement to qualify for the service and is not something to be optimised within dispatch, for example by registering, or dispatching, units with a wider deadband at lower volumes. This is because immediate response to very small changes in frequency is required for the service to be effective.

PFR-FCAS would be another "pair" of services dispatched in the same way as the other FCAS services and would therefore have 10 bid bands and offers would need to be no less than $0/megawatt hour (MWh). The service would be expressed with the usual FCAS bid and technical parameters to create a "trapezium" with breakpoint, angle, enablement max and min, and max availability – as per the FCAS model in the NEM Dispatch Engine (NEMDE).

Unlike Contingency FCAS, the maximum availability used could be scaled as per the droop setting. This is shown in the figure (right) from AEMO's report, *FCAS Model in NEMDE Scaling, Enablement, and Co-Optimisation of FCAS Offers in Central Dispatch*[14], explaining how the FCAS model works in dispatch.



4.2 Scaling for AGC ramp rates

NEMDE uses the more restrictive of offer Max Availability and AGC ramping capability for regulating service maximum availability. The AGC ramping capability is calculated as the AGC ramp rate multiplied by the interval time period. For example, if the AGC ramp rate is 5MW/min, the AGC ramping capability for a 5-minute dispatch interval is 25MW (i.e. 5MW/min x 5 minutes = 25MW). If the AGC ramping capability is more restrictive than the offer Max Availability, NEMDE scales the trapezium by using the AGC ramping capability as the effective Max Availability, and adjusts the trapezium break points to maintain the trapezium angles. If the AGC ramping capability is higher than the offer Max Availability, the scaling has no impact. If the AGC ramp rate is zero or absent, no scaling is applied.

Scaling by AGC ramp rates is shown in Figure 7.

Figure 7: FCAS trapezium scaling by AGC ramp rates

Units would need to notify a droop setting, and this could be included in the technical parameters and bid files submitted to AEMO.

Please note units would be unable to offer a different price for operating at a lower droop value (more aggressive). This is similar to regulation FCAS, where units with a higher ramp rate can sell more FCAS, but they cannot be paid more for the same FCAS enabled, if the quantity does not use the full ramp rate.

[14] At https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Dispatch/Policy_and_Process/2017/FCAS-Model-in-NEMDE.pdf.

Payment

- PFR-FCAS providers will be paid for the enabled amount, exactly as the other Regulation FCAS and Contingency FCAS services.

Charges

- Prices will be formed by the usual FCAS arrangements, using the sum of marginal value of the constraints (requirements) that apply to the region.
- As per Regulation FCAS requirements, costs of constraints will result in the allocation of costs per participant factors.
- All costs distributed within the trading interval (every five minutes after 5-minute settlement).

A1.1.3 PFR-FCAS – discussion as replacement to tight MPFR

With tight MPFR, there should generally be no requirement for the system to procure reserves, because reserves are procured through the Contingency FCAS and Regulation FCAS markets and generally available on the system from incentives to provide adequate capacity in the energy market.

The original premise of PFR-FCAS is in widening the deadband and reinstituting control by enabling a smaller number of units to provide primary control. By using a smaller number of units, these units will respond to the now faster changes in frequency with primary response, called "PFR duty". The thinking would be that this should allow for economising on primary response and to allow those units that are cheapest to provide it. For PFR duty to be concentrated on a few units, and if these units respond with a droop setting close to or equivalent to the setting under MPFR, frequency will not be controlled as tightly to 50 Hz. This means the droop of individual PFR-FCAS units, and the aggregate droop they provide, is important.

Under the current MPFR, there is no aggregate quantity and speed of response established. With all units on MPFR, the amount is dependent on the availability of units in the NEM and will vary depending on system conditions. It should be noted the Regulation and Contingency FCAS markets do preserve a quantity and with the specified droop at a maximum of 5% under the MPFR, subject to these markets not being dominated by switched response, a minimum performance is offered.

Noting Section A1.1.1, a market service requires establishing a service standard to allow AEMO to set requirements in dispatch. This is because consumers cannot directly express a preference for a level of service or directly purchase the amount of service they desire.

PFR-FCAS requires AEMO to establish both an aggregate dispatch requirement in MW and an aggregate MW/Hz requirement for primary control. The second requirement is needed because there is no direct equivalence between amounts dispatched between units unless the droop setting is accounted for.

It is possible the standard may deliberately allow less control of frequency than is achieved under MPFR – the PFR-FCAS may try to set a level of frequency control that consumers are only willing to pay for. This implies it is inefficient to spend more money to control frequency any better than the standard. AEMO considers this is more likely to reduce the effectiveness of secondary control, create unnecessary primary duty, and increase overall costs.

PFR-FCAS assumes some equivalence to the PFR duty on the larger fleet of units under MPFR, as compared to a subset of units enabled for PFR-FCAS. This is because the implied benefit of PFR-FCAS is to concentrate PFR duty on those units that can provide it most cheaply. The economic benefit of the PFR-FCAS will be to reduce the costs of PFR duty. AEMO considers this assumption is simplistic, because with tight deadband MPFR frequency could be tightly controlled so that aggregate PFR duty is minimised, allowing secondary control to perform its job of correcting energy imbalances.

A new PFR-FCAS service will require those units enabled to operate with a tight or no deadband and a specified droop. AEMO assumes PFR-FCAS and Regulation FCAS would be mutually exclusive at a system and unit level. Given the service will be specified differently than Regulation FCAS, the service may clear with different prices, depending on the mix of suppliers that qualify. It is likely Regulation FCAS and PFR-FCAS will be very similar, and the same providers would offer both services.

Yet, unlike the other FCAS services, it also leads to a premise that AEMO could dispatch more primary reserves and less secondary control reserves depending on their cost. Because these controls are not directly substitutable, (they do different jobs), this premise is incorrect.

For example, with PFR-FCAS and a wide MPFR deadband, the system could revert from ubiquitous, tight deadband MPFR to only a few units being on PFR-FCAS. Only under extreme scarcity conditions would this not result in a reduction in primary control unless the enabled units have very aggressive droop settings. AEMO assumes a system with PFR-FCAS rather than tight MPFR will have less control , which can undermine the secondary controls, resulting in Regulation FCAS being deployed to less effect.

Therefore, AEMO believes any assumption that primary and secondary control can be optimised by dispatch to be wrong. The two controls do different things; secondary control, when tuned effectively and in the absence of a contingency, provides the energy correction, which can be procured in economic dispatch, utilised through AGC within the five minutes, and settled through a cost allocation mechanism like that specified in the Causer Pays Procedure. Less droop response cannot be compensated for with more secondary control and vice versa. For these reasons, AEMO would institute requirements for Regulation FCAS and PFR-FCAS independently of each other in dispatch.

A1.1.4 What is the PFR-FCAS procuring – MW/Hz or MW?

The design of PFR-FCAS, as specified above, procures reserve MW because this is a prerequisite for integration into security constrained economic dispatch. The service as specified also requires the MW requirement to be met at an aggregate MW/Hz. This would have the effect of procuring more from units with a more aggressive droop response. This is the only way of concentrating the service on a few units (rather than the whole fleet) without degrading control (allowing a wider frequency error), and would, by proxy, value aggressive droop.

AEMO considers it important to restore primary control for normal operation, not to encourage aggressive droop settings on a few units.

As discussed earlier, to get the same control of frequency when concentrating a service onto fewer units, this must be compensated by a more aggressive droop setting.

The following two figures indicate how a PFR-FCAS may work, depending on allowable frequency error, unit droop settings and rated capacity of online plant, using the data tables in the AEMO Technical White Paper that accompanies this paper.

Figure 13 shows the gross rated capacity of online plant that is required to be able to provide primary control, for a given 250 MW error (250 MW is therefore the "requirement" in megawatts procured in dispatch).

To provide the 250 MW, the gross rated capacity of those units enabled to provide PFR-FCAS service is a function of the droop setting and allowable frequency error. The droop setting is assumed to be consistent across all plant (it need not be), and the allowable frequency error is how tight the system should remain to 50Hz for the 250MW error. Figure 13 shows that, to keep frequency within +/-0.02 5Hz, 25 gigawatts (GW) of plant need to be at 5% droop.

Figure 14 shows that for the same requirement, no more than 1% of the rated capacity can be enabled, therefore across the 25 GW only 1 MW per 100 MW of capacity can be enabled.

To make the service more feasible, the droop on the unit can be made more aggressive, and/or the allowable frequency error can be widened. The frequency error can be widened to the edge of the NOFB, +/-0.15 Hz, then 417 MW of plant need to be at 0.5% droop. Figure 14 shows that for the same requirement, no more than 60% of the rated capacity can be enabled, therefore across the 417 MW, 60 MW per 100 MW of capacity can be enabled to provide the 250 MW.

Figure 13 Gross rated capacity of online suppliers

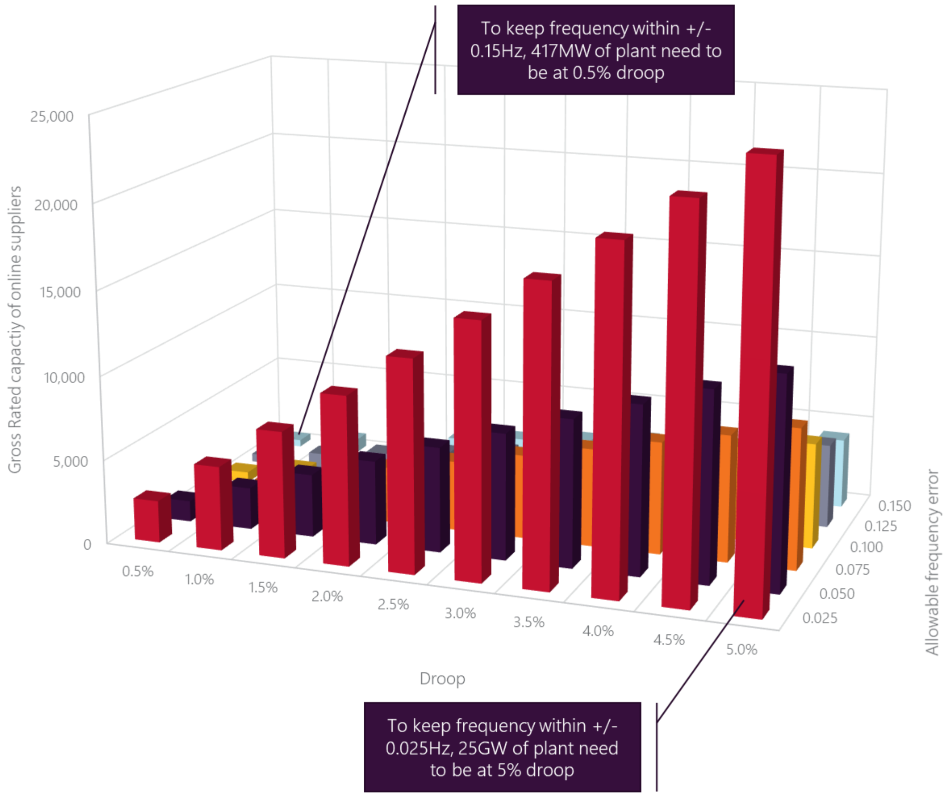
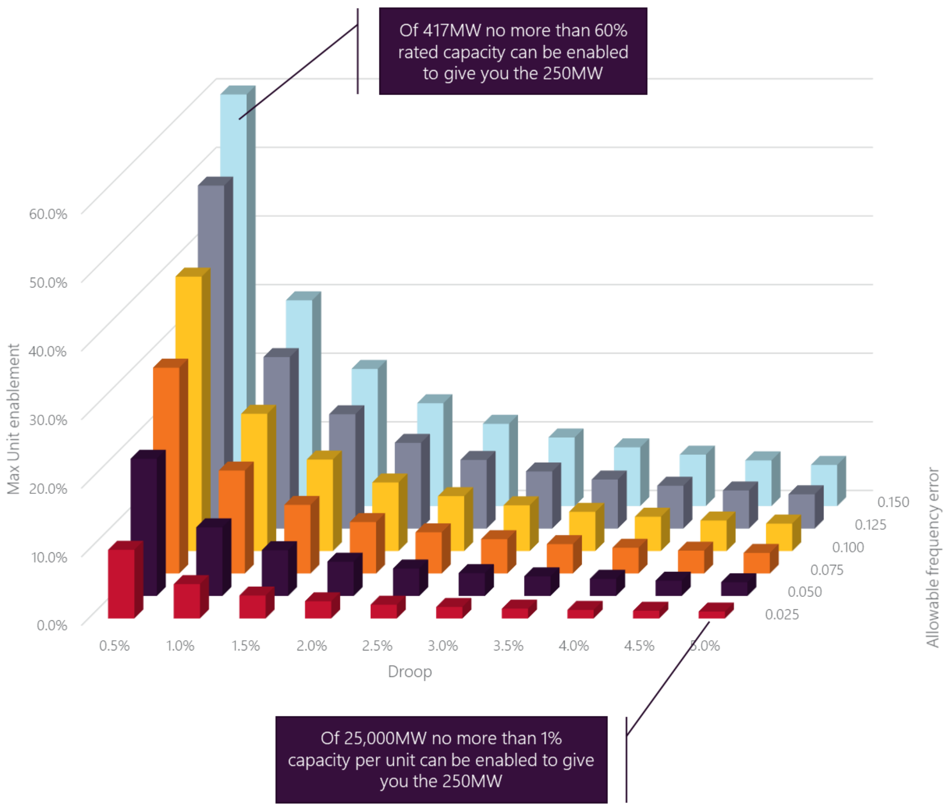


Figure 14 Maximum provision from each unit as % of rated capacity



This seems feasible; possibly a few batteries could provide the service. It is, however, unlikely the secondary control would work as effectively with such an allowable frequency error, and security limits may need to be respected in dispatch to restrict local concentrations of power output.

The conclusion AEMO takes from these analyses is not that a PFR-FCAS service is infeasible, but that a PFR-FCAS service is not easy to specify as a simple extension to security-constrained economic dispatch, which implies the service can be procured by procuring MW capacity like the existing FCAS services, that are premised on significant Hz error and measured unit response. By contrast, a PFR-FCAS is the procurement of control, not the procurement of response, and may need careful design and integration into dispatch, including the direct monitoring of unit droop settings, if it is to replace tight deadband MPFR.

A1.1.5 Example – Dynamic Regulation and Dynamic Moderation

The most interesting example of a system operator procuring narrow band primary response from a few providers is National Grid Electricity System Operator (NG-ESO). It intends to procure 400-600 MW of 10-second response to operate between 0.015 Hz and 0.2 Hz. This is called Dynamic Regulation.

While the United Kingdom (UK) operates with a requirement for 3-5% droop response as specified by the Connection and Use of System Code (CUSC) clause 4.1.3.2(ii), performance is only required under instruction by NG-ESO, and instruction is moderated through providers issuing "holding" prices and "response energy" prices, in monthly sales. Non-mandated units can also sell services, against mandated units, and the arrangements are called Firm Frequency Response.

Like all balancing services in the UK, Firm Frequency Response and Dynamic Regulation are not "co-optimised" in energy dispatch and each operates with its own market clearing rules. For example, Dynamic Regulation is likely to be procured day-ahead. There is no directly comparable AGC Regulation service, because there is no directly comparable security-constrained economic dispatch. Instead, the UK system also includes bid-offer-acceptances (BOAs) for redispatch after gate closure and in real time, to allow NG-ESO to adjust generator loading in response to dispatch errors.

This service, say 500 MW, would provide an aggregate droop response of 2,500 MW/Hz and provides slow proportional control to slow changes in frequency within +/-0.1 Hz. The assumption behind Dynamic Regulation appears to be an allowable range of +/-0.1 Hz, where frequency is controlled by slow, proportional response for small deviations.

NG-ESO is required to keep frequency within +/-0.5 Hz. It aims to do this by managing day-to-day variability to +/-0.2 Hz and contingencies of the size 1 GW-1.4 GW to +/-0.2-0.5 Hz.

The Dynamic Regulation service is therefore supplemented by 300-500 MW of Dynamic Moderation, which provides sub-one-second response between +/-0.1-0.2 Hz, and then 1,400 MW of Dynamic Containment, another sub-one-second service to manage large contingencies.

The reason for the Dynamic Moderation service is unclear, bar some recognition the 10-second response of Dynamic Regulation over the 0.015-0.2 Hz deviation may be too slow in a system with lower inertia to manage sudden large imbalances, like errors in wind forecasts.

While AEMO would consider the MW/Hz aggregate droop provided by the Dynamic Regulation service may provide insufficient control within the +/-0.2 Hz deviation, it is interesting to observe NG-ESO consider the solution is not to procure more supply of slow proportional response from Dynamic Regulation, but instead procure fast acting response from Dynamic Moderation.

A1.1.6 PFR-FCAS – discussion as a complement with tight MPFR

The previous discussion focused almost entirely on the use of a PFR-FCAS as an alternative to tight deadband MPFR. AEMO's recommended option (1b) is to retain tight deadband MPFR and improve cost allocation for regulation FCAS through replacing the causer pays system and instituting credits for positive performance, which may include primary response. AEMO considers this proposal resolves both the control and incentive elements of the problem, as explained in Section 2.

As previously stated, with tight MPFR there should generally be no requirement for the system to procure reserves. This is because reserves should be generally available on the system from incentives to provide adequate capacity in the energy and FCAS markets, and further encouraged by improving incentives in the Regulation FCAS cost allocation system, which should minimise any penalty for units on tight MPFR to provide reserves.

Additionally, it should be noted that the asset supply in batteries should more than meet demand for FCAS markets in the next few years, suggesting these markets could become saturated. This depends on the availability of existing providers of FCAS, because the very factors that are encouraging investment in batteries are also discouraging the continuing operation of synchronous generating units which may decommit or decommission.

Nevertheless, just as with generators, frequency services may become part of, and not the business case for, batteries, and these would need to make money from merchant energy provision, because frequency services prices, particularly especially for normal operation, should drop to energy market opportunity costs. This is one of the benefits of co-optimised dispatch of energy and FCAS.

It is possible to identify conditions that may lead to a lessening of available capacity reserves for primary control. Under tight MPFR this can only occur if the available supply either cannot provide primary control (for example, is exempted under the mandate, like distributed residential solar or distributed storage), or does not provide adequate reserve headroom. The controllability/visibility of distributed services, prevalence of them, and adequate provision of reserves at those times are wider questions and not solely related to primary control. They also tend to be of concern when imagining non-credible contingencies occurring, and are not usually the realm of market services, unless subject to the Protected Event framework of the NER.

AEMO considers it appropriate to assume that something will be done, either by participants themselves or the market bodies, to provide controllability/visibility and adequate reserves. This then allows the question to be limited to whether the power system retains enough primary control under those circumstances. This question has more validity, because there will be resources to which the MPFR obligation does not apply, and these resources may not easily be exposed to improved incentives via causer pays.

For these reasons, AEMO considers it sensible to assess, track and possibly report on the aggregate frequency responsiveness of the NEM, including assessments of the capacity that is available to provide primary control. AEMO may then investigate whether primary control is reducing under certain system conditions.

The recommended option may not encourage fast response for normal operation

This paper has highlighted the effects of the tight MPFR deadband and has recommended it be matched with better incentives to improve participant behaviour and minimise dispatch errors. AEMO would expect these incentives to minimise any negative effects of mandating primary control.

AEMO considers normal operation would typically be dealing with small rapid deviations, or large slow deviations, that occur within the dispatch interval. By contrast, Contingency FCAS deals with large, fast deviations in frequency caused by larger, instantaneous trips of plant. For these reasons, slow proportional response and secondary response should be adequate for good control under normal operation.

As endorsed by AEMO, the AEMC has recently determined[15] the NEM needs a new "very fast" contingency FCAS service to ensure the frequency nadir is adequately arrested in a system with lower mainland inertia.

AEMO recognises the recommended option (1b) provides slow acting response:

- Interim Primary Frequency Response Requirements (IPFRR)[16] specifies units should operate with a tight deadband of +/-0.015 Hz, at 5% droop and sufficiently fast to alter output by at least 5% within 10 seconds.

[15] AEMC, Fast Frequency Response Market Ancillary Service, Final Report, 15 July 2021, at https://www.aemc.gov.au/rule-changes/fast-frequency-response-market-ancillary-service.

[16] At https://aemo.com.au/en/initiatives/major-programs/primary-frequency-response.

- Replacing the existing Regulation FCAS cost allocation system to improve incentive arrangements relies on measuring unit dispatch errors every 4 seconds.
- Whilst faster acting primary control may mitigate some effects of declining inertia, it may not be sensible to implement a very fast acting primary control service instead of directly procuring inertia. There are different sources of synchronous inertia and possible substitutes from fast acting inverter technologies. For example, in South Australia the minimum threshold level of inertia that must be provided continuously, (of 4,400 megawatt seconds [MWs] to ensure the system is satisfactory after islanding), is to be provided by four synchronous condensers, and the secure level of inertia (which is required only after islanding) may be provided by "Inertia Support Activities" from inverter technologies. The commitment of synchronous generators may also provide inertia.
- Like the issue of controllability/visibility of resources and provision of adequate reserves, AEMO considers it appropriate to assume that something will be done by the market bodies to provide adequate levels of inertia to operate the system. Notwithstanding this, AEMO acknowledges the recommendations in this paper are focused on slower response, more appropriate for a system where fast responses are not required, because inertia or its substitutes are provided for. There may be options to improve this, such as measuring some providers using data collected at intervals less than 4 seconds.
- AEMO considers there may be merit in further investigating this problem and, in time, revisiting whether procurement of faster acting response is required for small frequency deviations. It should be noted this question was not part of the original brief for this advice, where instead the focus was on comparing the performance of a new PFR-FCAS as opposed to tight deadband MPFR.

A1.2 PFR-FCAS summary

Security-constrained economic dispatch procures FCAS requirements as part of an overall optimisation which includes meeting regional demand (MW), unit, and locational constraints. The quantity of FCAS a provider may offer into the dispatch optimisation is calculated prior to registration for the market services, consistent with the MASS. For proportional response services, like Contingency FCAS, this will reflect the unit droop settings and speed of response over each FCAS service's specified timeframes (fast, slow, delayed).

It is in the creation of multiple services, over different timeframes, in the MASS that commodifies different responses from generating units or loads and allows a relatively simple deployment of FCAS into dispatch. FCAS can then be dispatched like energy and prices can be derived from the co-optimisation of energy and FCAS services using constraints (requirements) and dispatch offers for each service.

This section has outlined a possible deployment of a new FCAS service for PFR and highlighted some complexities that arise from the engineering requirements for primary control.

Unlike Contingency FCAS, where the response is measured against a significant frequency error (as specified by AEMO at registration in the MASS), a PFR-FCAS service is less concerned with procuring some reserve MW, equivalent to the energy response in proportion to a known frequency ramp/error, but instead more concerned with preserving an aggregate frequency responsiveness in MW/Hz. This means megawatts from suppliers cannot be economised in dispatch on a like-for-like basis, and would require allowing unit droop measurements to be accounted for, where units with more aggressive droop response are of greater value to others. A more radical proposition would be to integrate droop into dispatch in some way, for example allowing dispatch to require the unit to adjust its droop. This would allow the droop to be a controllable variable, or output, from dispatch, rather than simply an input into the dispatch optimisation.

For these reasons, a new service may be feasible to integrate into dispatch, but it would not simply be a replica of the existing FCAS which uses the security constrained economic dispatch to "require" a MW reserve quantity from resources where the quantity of FCAS is already specified.

AEMO does not consider procuring a MW requirement quantity, like the other FCAS services, to be a pressing reason to implement a new PFR-FCAS service. This is because the procurement of capacity reserve, or MW, is not directly correlated to primary control, unless the system is under very tight reserve conditions or those reserves are unable or exempt from tight MPFR. These are conditions that should be avoided, either through general incentives to provide reserves in the energy market and/or the actions to encourage distributed resources to either provide the necessary services, like PFR or be subject to constraints.

A more interesting question is whether faster acting primary control may be required in a system with reducing synchronous inertia. The recommendations in this paper focus on slow proportional response and good dispatch controls, measured every 4 seconds. While this may encourage some faster response from providers, it is unlikely to encourage primary control in ~1 second timeframes to compensate for a future with lower inertia.

The NG-ESO's proposal for new "end state" services within +/-0.2 Hz, that include layered response, with slow acting response at a very tight deadband and then very fast response from +/-0.1-0.2 Hz, is an interesting example because it suggests speed of response may be important for primary control in the future, and that speed could be acquired as part of a primary control service.

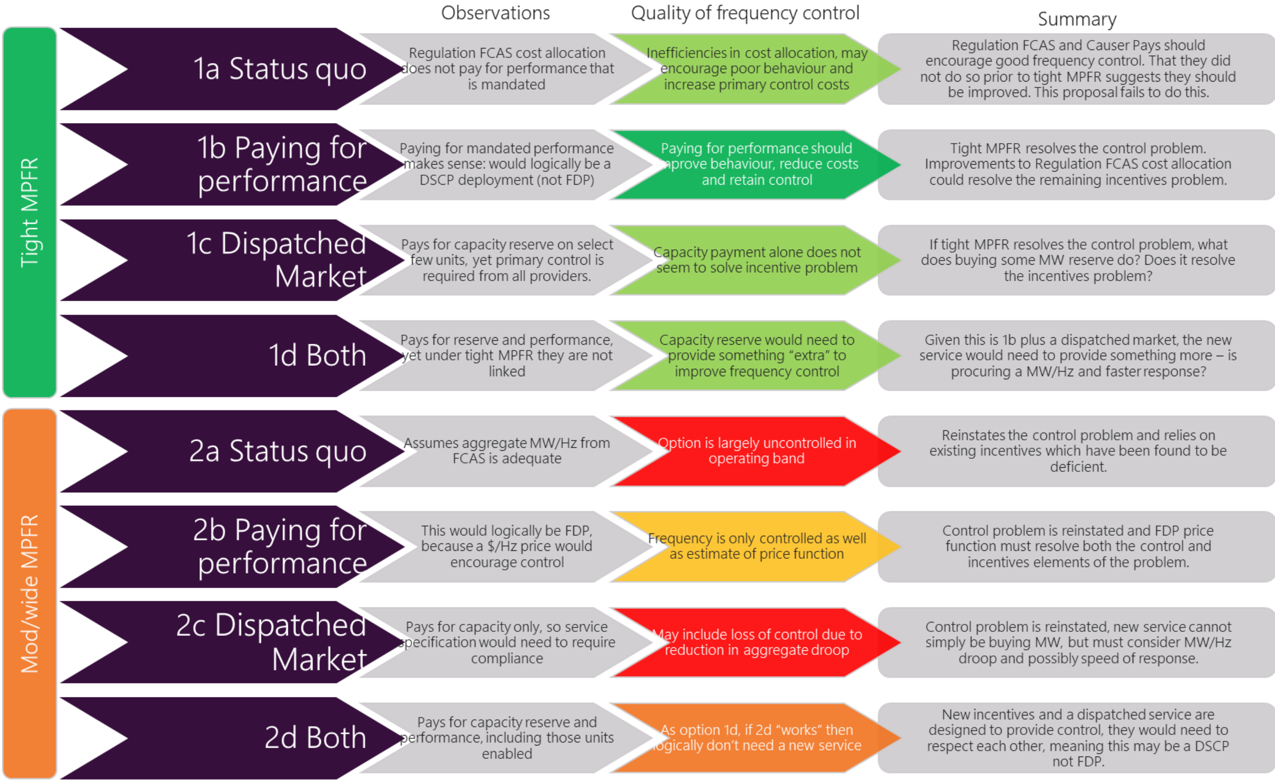
AEMO considers direct comparisons with the UK NG-ESO should not be made, because the UK power system and trading arrangements are fundamentally different to the NEM. For example, NG-ESO can simply procure services should it be incentivised to reduce balancing costs, whereas for AEMO the task is to integrate services into dispatch, formally specified alongside other services, and only once the NER requires AEMO to do so. Further, the fact NG-ESO intends to procure faster acting primary control does not prove that procuring faster acting proportional response is an ideal way to compensate for lower synchronous inertia. NG-ESO has also contracted directly for inertia and there may also be methods to acquire inertia substitutes.

A2. Evaluation of options

A2.1 High level summary

Figure 15 provides a summary evaluation of the options, highlights some observations, and makes a qualitative assessment of the quality of frequency control under each option. It is AEMO's opinion that no equivalence in terms of performance should be drawn between the options. This is because the Pathway 2 options, (2a-d), are deliberately premised on lessening primary control to a procured level.

Figure 15 High-level evaluation of AEMC options



A2.1.1 Option 1a – tight MPFR and status quo

This option retains the tight MPFR only. Given the current Regulation FCAS cost allocation system does not pay for positive performance, this would (largely) exclude compensating for good performance of primary control. Putting aside any debate about whether to incentivise primary control or secondary control, the inability of the Regulation FCAS cost allocation system to stop frequency deteriorating prior to the introduction of MPFR would indicate poor behaviour that causes a need for control is not effectively penalised under the existing incentives.

This is enough to suggest changes to the system are necessary. The reason to do this would be to minimise costs imposed on participants, rather than improve control, because with tight MPFR and well-tuned AGC Regulation FCAS, frequency control should be of an acceptable performance. Nevertheless, AEMO suspect poor cost allocations could potentially lead to more "demand" for these services manifesting itself in primary or secondary control duty.

The existence of tight MPFR and secondary control Regulation FCAS means this proposal, irrespective of any poor incentives due to deficiencies in the cost allocation of regulation FCAS, should provide a good quality of frequency control.

A2.1.2 Option 1b – tight MPFR and paying for performance

Building on the discussion of 1a, this option recognises the importance of tight primary control to provide a strong base, but recognises this can be enhanced through better cost allocation mechanisms, including revisions to the Regulation FCAS cost allocation system, including paying for performance.

With tight MPFR, it would be logical for this to be a "double-sided causer pays" (DSCP) deployment, because why would a price incentive be needed to encourage the correct control, like FDP, when the control is already specified through a required deadband and droop on all units?

In this example, there is no new dispatched market for primary control, so AEMO concludes the DSCP deployment would be a revision to the existing Regulation FCAS cost allocation system: it would be focused on secondary control and consistent with AEMO's preferred approach outlined in this paper. This is an important distinction – it is not pricing primary control, but more effectively allocating the costs of secondary control (notwithstanding AEMO's advice explaining how the primary and secondary controls interrelate). AEMO also accepts that where there is primary response or duty, this should be rewarded in any revisions to the existing Regulation FCAS cost allocation system.

This option is consistent with the premise that primary and secondary control are not directly substitutable; tight deadband MPFR controls changes in frequency so the secondary service and its cost allocation system provide the economic benefits from concentrating error correction on the most efficient units, and it is possible to develop incentives for dispatch of secondary control and its cost allocation to mitigate any distortion tight MPFR could introduce.

As in Option 1a, the existence of tight MPFR, secondary control Regulation FCAS, and tertiary control means this proposal will provide a good quality of frequency control, and in addition costs should be minimised and possibly performance improved by resolving poor incentives that existing in the existing cost allocation of Regulation FCAS.

A2.1.3 Option 1c – tight MPFR and a new dispatched market

This proposal is not coherent, because it procures new capacity reserves for primary control and yet mandates the performance of all generating units, not just those units from where the reserve is procured. Additionally, it does nothing to resolve inefficiencies in the existing causer pays system.

Like options 1a and 1b, this proposal should provide a good quality of frequency control, however AEMO believes a new dispatched market that simply buys capacity reserves would add little.

The procurement of capacity reserves does not directly relate to the way AEMO has evaluated the problem in this report, which relates to reinstating control and improving incentives. The procurement of reserves is, under most conditions, uncorrelated to primary control and behavioural incentives given effect by cost allocations are not resolved by the presence of a dispatched market in NEMDE.

While Section A1.2 discussed ways of making a new dispatched market useful, by integrating droop into the dispatch optimisation and/or procuring services from faster primary response, Option 1c fails to directly address the incentive elements of the problem.

A2.1.4 Option 1d – tight MPFR, both

This proposal appears to build on the recommendations from Option 1b, but then includes the recommendation for a capacity reserve to be acquired for primary control. It is unclear whether the proposal is for a new DSCP to go with the new market, or the existing Regulation FCAS cost allocation system is changed to being double-sided and recovers cost of both a new dispatched market and Regulation FCAS.

AEMO suggests Option 1b is a sensible proposition, but for the reasons given in A2.1.3 it does not automatically follow that a new dispatched market is also needed with tight MPFR. The creation of a new dispatched market creates another cost that must be recovered by the cost allocation system. If there is not a demonstrable need for this service, this extra cost may needlessly distort the cost allocation and reduce its effectiveness.

Like options 1a, 1b, and 1c, this proposal should provide a good quality of frequency control, because it includes tight MPFR; however, a new dispatched market may detract from the primary solution, which is to improve on the existing cost allocation mechanism for Regulation FCAS, which can be achieved with Option 1b.

Section A1.1.6 discussed the potential for a PFR-FCAS to supplement tight MPFR with improved incentives (Option 1b), which could be used to preserve an aggregate frequency responsiveness (in MW/Hz) and to possibly increase the speed of primary response in a system with lower inertia. It is in specifying these requirements, where a new dispatched market would directly improve frequency control outcomes, when a new service would be a useful addition to Option 1b.

Over Option 1b, there appears no immediate requirement to introduce a dispatched market, the features of which should be considered as the power system changes.

A2.1.5 Option 2a – wider MPFR and existing FCAS providers on tight PFR

This proposal requires only existing FCAS providers in the Contingency and Regulation FCAS markets to operate with tight primary control. Because the existing Contingency and Regulation FCAS requirements are set to replace the energy lost during a credible contingency (Contingency FCAS), or persistent frequency error (Regulation FCAS), they are not enough to provide an aggregate droop response to control the change in frequency. This means it is likely the control of frequency in the operating band will deteriorate and secondary control will be less effective. Contingency and Regulation FCAS reserves are not enough to provide the aggregate droop response needed for good control. This is not recommended.

A2.1.6 Option 2b – wider MPFR and performance payments

This proposal assumes that a price incentive can encourage a good quality of frequency control within the operating band. For this reason, AEMO assumes this deployment would be more like FDP (and not DSCP), because no market would be required. The quality of frequency control would depend on the quality of the price function. AEMO notes this option would start from a low control base (by the absence of tight MPFR) and then must encourage the correct response.

It is AEMO’s opinion that any deployment of FDP would not simply incentivise primary control as if it were entirely separable from secondary control. Instead, the FDP would include elements of both primary and secondary control and measure performance in the achievement of good frequency control. To abstract FDP for primary control is unnecessary and would probably undermine the design of any such price incentive.

AEMO does not recommend this option.

A2.1.7 Option 2c – wider MPFR and new dispatched market

This proposal assumes frequency can be controlled by a proportion of generators that are enabled to provide primary control. As explained in Appendix A1.1.3, it is difficult to envisage how a high aggregate droop could be maintained, even if enabled units operate with far more aggressive droop settings. For this reason, AEMO concludes this service must be premised on widening the allowable frequency error.

If primary control were adequately provided by acquiring a few hundred megawatts of capacity reserve from the energy market and could readily be concentrated on a few units, this solution would be ideal. It would only be under very tight reserve conditions that aggregate droop of the system would be correlated to the simple purchase of reserves. For the reason security-constrained economic dispatch operates with the assumption of free flow of frequency response across the synchronous region, the service would need to respect power system security limits.

AEMO notes this option would start from a low control base, due to the absence of tight MPFR, and then must encourage the correct response from the enabled units.

For reasons given earlier in this section, AEMO does not recommend this option.

A2.1.8 Option 2d – wider MPFR, both

This proposal is like a DSCP for the new primary control dispatched market. It is unlikely to be FDP, because if this were possible then Option 2b should be implemented. Like Option 2c, this option is premised on primary control being something that can be minimised rather than maximised, and assumes it has a material economic cost that needs to be minimised. AEMO does not agree with these premises.

AEMO notes this option would start from a low control base, due to the absence of tight MPFR, and then must encourage the correct response from the enabled units and/or through the double-siding of its cost recovery. For reasons given earlier in this section, AEMO does not recommend this option.